



IMPERIAL BUREAU OF  
HORTICULTURE AND PLANTATION CROPS

TECHNICAL COMMUNICATION No. 11

FRUIT JUICES AND RELATED PRODUCTS

By

V. L. S. CHARLEY, B.Sc. (Hons.) BRISTOL

and

T. H. J. HARRISON, D.Sc. Agric. (SYDNEY), D.I.C. (LOND.)

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# FRUIT JUICES AND RELATED PRODUCTS

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## FOREWORD

By NEVILL L. WRIGHT, F.I.C., D.I.C., Scientific Liaison Officer for the New Zealand Department of Scientific and Industrial Research, London.

There is a growing realization amongst those concerned in the British Empire of the potential importance to the fruit industry of a development which has assumed very large proportions in Europe, notably in Germany and Switzerland, and in America. This is the establishment of a flourishing and increasing industry based on the efficient and profitable utilization of fruit—principally apples, grapes, citrus fruits, pineapples and tomatoes—in the form of naturally unfermented fruit juices.

The fruit producer has always had difficulty in disposing of fruit below a certain standard, but which, nevertheless, is edible and nutritious.

The establishment of a profitable outlet for the disposal of such fruit in the form of a natural juice such as apple and grape juice and also of fruit syrups made from berry fruits would—it is believed—solve the problem and would simultaneously assist the producer and provide nourishing and stimulating beverages for the consuming public.

As one who has become an ardent advocate for the exploitation of the industry within the Empire it gives me great pleasure to have this opportunity of conveying to Mr. V. L. S. Charley of the Long Ashton Fruit Research Station, England, our grateful appreciation for writing this valuable and fascinating account of the fruit beverages industry in conjunction with Dr. T. H. Harrison, Fruit Research Officer of the Australian Department of Commerce.

Mr. Charley has carried out magnificent work on this subject which, until recently, has attracted surprisingly little attention within the Empire with the notable exception of South Africa, where one of the largest units in the world producing natural grape juice is operating.

It is sincerely hoped that this publication will have the effect of stimulating urgent consideration by those concerned, both in State Departments and in the industry itself, of the best way of taking advantage of the fund of knowledge available.

As Chairman of the Executive Council of the Imperial Agricultural Bureaux, and as one who has maintained the closest association with the development on behalf of my own Government in New Zealand, I sincerely hope and believe that this publication, which has been rendered possible by the existence of the Imperial Bureau of Horticulture and Plantation Crops, will achieve its objective by promoting the development of the potentially valuable adjunct to the fruit-growing industry of the Empire.

London.

August 23rd, 1938.

## INTRODUCTION

This Technical Communication has been compiled at the request of the Imperial Bureau of Fruit Production, which has been impressed by the rapid development of the fruit juice and related industries in other countries during the past five years, and by the absence of a sufficiently comprehensive source of reference in English.

Requests for information from technical workers and commercial organizations throughout the Empire have shown the need for such a publication. It is hoped that it will not only answer most of the questions now being directed to Research Stations, but will be of assistance in hastening the development of a healthy fruit juice industry in all parts of the Empire where fruit growing is of importance.

Because of the particular interest being expressed in England, Canada, New Zealand and Australia, in apple juice, emphasis is laid on the production of this juice, but it is considered that the general principles enumerated in this connection will be applicable to other juices.

In endeavouring to piece together the various fragments of information necessary to the presentation of a connected story the authors have been troubled by the very dynamic nature of the industry which is still relatively so young.

Thus, new information is constantly becoming available and frequently, while the manuscript was actually in draft, it became necessary to modify the text or shift the emphasis in the light of some new development. It is therefore hoped that it may be possible to issue supplements to this Technical Communication from time to time.

The Imperial Bureau of Fruit Production and the authors would appreciate the co-operation of those who read this publication in directing attention to any information which may be useful in connection with such a supplement.

Correspondence on this subject should be forwarded to the Deputy Director, Imperial Bureau of Fruit Production, East Malling Research Station, East Malling, Maidstone, Kent.

## PART I

### ECONOMIC AND NUTRITIONAL ASPECTS

#### 1. Economic and commercial considerations

##### A. *Scope of the industry*

One of the most romantic developments in any industry associated with the utilization of primary products has been that of the production of unfermented fruit juices during the last ten years. In some places a very limited output has been maintained since the beginning of this century, but it has been almost entirely in the last decade that this industry has, both in America and Europe, become one of major importance, not only affecting the economic well-being of the fruit producers, but also modifying the nutritional habits and health of the nations concerned.

The following tables not only indicate the stupendous rate of growth, but show clearly the enormous quantities of fruit juice which are now being consumed.

TABLE I  
PRODUCTION OF APPLE JUICE IN GERMANY

| Year. | Millions (approx.). |                   |
|-------|---------------------|-------------------|
|       | Litres.             | Imperial gallons. |
| 1926  | 2.25                | 0.5               |
| 1929  | 10.0                | 2.0               |
| 1931  | 18.0                | 4.0               |
| 1932  | 29.25               | 6.5               |
| 1934  | 36.0                | 8.0               |
| 1935  | 36.0                | 8.0               |
| 1936  | 24.75               | 5.5               |
| 1937  | 67.5                | 15.0              |

Some idea of the magnitude of the industry can be obtained by a consideration of the quantities of fruit required for the above output of juice. Two instances will suffice for this purpose. The apple juice figures for Germany for the year 1937 represent the equivalent of approximately  $4\frac{1}{2}$  million bushels of apples—a figure approximating to the total annual export of this fruit from Australia to the United Kingdom and Europe. The 1937 citrus juice total of 11,688,000 cases, in Table II, represents the equivalent of approximately 300,000 tons of fruit, which is approximately half of the annual average total citrus imports to the United Kingdom.

In many countries besides those mentioned above unfermented fruit juice production has already become an established industry. In 1937 the approximate production was as follows:

|                |    |    |    |    |           |                      |
|----------------|----|----|----|----|-----------|----------------------|
| Switzerland    | .. | .. | .. | .. | 8,000,000 | gallons*             |
| Austria        | .. | .. | .. | .. | 850,000   | „                    |
| Czechoslovakia | .. | .. | .. | .. | 400,000   | „                    |
| Poland         | .. | .. | .. | .. | 60,000    | „                    |
| Hungary        | .. | .. | .. | .. | 35,000    | „                    |
| England        | .. | .. | .. | .. | 60,000    | „ (including syrups) |

\* Information supplied by Swiss consulate, London.



In addition appreciable quantities were produced in Holland, Belgium, Italy, Canada, France, Sweden, Japan, Australia, New Zealand, South Africa, Malay and the Argentine. The fruit juice industry is therefore one which is rapidly becoming world-wide. Indications are that an adequate realization of the potentialities in fruit juices is quickly spreading. In some countries, such as Switzerland, Germany and U.S.A., the public has already become "fruit juice conscious" and is demanding more juice of certain types than the producers are in a position to supply.

It is obvious that the developments represented above could have taken place only because the production of fruit juices satisfied fully not only the requirements of the producers, but also the demands of the consumers. In addition, it must be clear that the various technical problems associated with its production and the inevitable demands of commerce for satisfactory margins of profit in developing and handling these new products have been satisfactorily met.

It may be wondered why in some countries certain juices appear to be much more popular than others. This may be due in part to differences in consumer preference, but is primarily due to the availability of supplies of fruit from which the juices are extracted. For instance, in America the juices consumed in largest quantities are orange, grapefruit, tomato and pineapple. The first three fruits are grown extensively on the mainland, and the fourth in Hawaii, the industries concerned being faced with the necessity of disposing of an enormous surplus production. In Holland the most popular juice is tomato, because the fruit is so readily available, one firm alone selling approximately 750,000 litres of this drink in 1937. In Germany and Switzerland and several other continental countries the most popular juice is apple, simply because the apple was the fruit most readily available for large-scale juice production. In South Africa the only juice produced on a large scale at present is grape, a fact for which the production of grapes in excess of the requirements of the wine industry is very largely responsible. Profitable outlets for other fruits in most years have been available to producers in that country.

It is obvious that a permanent fruit juice industry, of the magnitude represented by the above figures of production, can be developed only where there are available each year large supplies of raw material at a reasonable rate.

It would appear, too, that costs of distribution must be reduced to a minimum if the price at which the article reaches the consumer is to be such as to encourage consumption of large quantities of the juice. This point is eloquently made in a recent article by Polzer (74), who contends that the German public is entitled to have fruit juice—an essential food—at prices within the purchasing power of the average person. He claims that apple juice normally costs the retailer only 14 pf. per glass of  $\frac{1}{2}$  litre, and should be sold at not more than 25-30 pf., in contrast to the average of 60-80 pf. at present in vogue. He rightly insists, however, that quality must not be sacrificed to price, and urges the establishment of fruit juice factories near the main centres of population.

For that reason it is primarily an industry which must depend on its "home market" for its main support. Despite the use of concentrates for reducing transport costs, the home producer may rest assured that this factor will fairly effectively protect him against the imported article, providing that he is in a position to produce fruit juices at a reasonable figure. It may never be economic for each country to attempt production of all types of fruit juice. To regulate importation of those juices likely to reduce consumption of those being produced locally is a matter to which each country must give attention, but it should always be kept in mind that to a certain extent different types of fruit juice help each other. In that connection concentrates will undoubtedly play an important part. Legislation is already in force in one country, Germany, defining clearly the uses to which the concentrates may be put, and it is anticipated that the same will apply elsewhere in due course.

### *B. Cost of production*

It is now necessary to consider briefly the costs of production. It is obvious at the outset that these must vary tremendously as a result of the many variables of which the following are perhaps the most important:

- (a) The cost of the raw fruit.
- (b) The method of production of the juice, including variation in overhead costs.
- (c) The volume of output.
- (d) Costs of distribution.

As it is outside the scope of this communication to specify in detail the plant and equipment necessary for each type of fruit juice, and obviously impossible to consider the various permutations and combinations of the many variables, no attempt will be made to discuss this matter in detail. Nevertheless, in connection with apple juice production there are available some figures which may be useful as a guide to those contemplating production of this juice.

In U.S.A. the Department of Agriculture has issued an outline (81) of approximate costs, compiled from data collected in its laboratory at Pullman, Washington. From this it appears that when apples cost 7 dollars per ton the juice costs  $4\frac{1}{2}$  cents ( $2\frac{1}{4}$  d.) per gallon for raw material, but the production and distribution costs cause this to rise to  $31\frac{3}{4}$  cents (1s. 4d.) per gallon as the net wholesale cost in cans. These figures are for a factory with an output of approximately 3,500 gallons a day, with plant estimated to cost approximately 10,000 dollars. The margin between wholesale and retail prices is not known, but on the basis of a minimum of 50% spread it is calculated that the retail price of the above juice would be approximately 2s. per gallon. In that connection it is necessary to remember that there is much road-side selling by fruit growers in the Western States of U.S.A. at retail prices even below the figure mentioned above. This is easily understood when it is considered that not only are costs of distribution dispensed with but only such quantities pressed as are commensurate with the road-side demand, and thus costs of storage, clarification, etc., are avoided.

In Germany certain figures are available from a factory with a daily pressing capacity of about 50 tons (1,000 centals) and a total output of approximately 175,000 gallons or 800,000 litres. The apples were purchased at 7 marks per cental—a price fixed by the Reich Ministry. A yield of 38 litres per cental was obtained, hence the cost of the raw material was equivalent to approximately 18½ pf. per litre. This material was sold to shopkeepers at approximately 75 pf. per litre in three-quarter litre bottles on which a charge of 20 pf. was made. The retail price was approximately 107 pf. per litre. Translating the German mark at the nominal rate of twenty to the pound, the above figures represent the following:

|                      |    |    |    |    |                             |
|----------------------|----|----|----|----|-----------------------------|
| Price of apples      | .. | .. | .. | .. | £7 per ton.                 |
| Yield                | .. | .. | .. | .. | 170 gallons per ton approx. |
| Cost of raw material | .. | .. | .. | .. | 10d. per gallon. approx.    |
| Wholesale price      | .. | .. | .. | .. | 3s. 4½d. per gallon.        |
| Retail price         | .. | .. | .. | .. | 4s. 10½d. per gallon.       |

In Germany, however, there are many factories which manufacture fruit juice from fruit supplied by customers in payment for pressing services rendered by the companies. Thus not only do the companies receive their fruit at nominal prices but the suppliers get their fruit pressed on the same basis. Such an arrangement has been in part responsible for the tremendous growth of the apple juice industry in Germany, and it is obvious that the costs per litre must be considerably below those mentioned above. The rapid growth of apple juice factories in Germany since 1932 is indicated in the following Table.

TABLE 3

| Year. | No. of factories. |
|-------|-------------------|
| 1932  | 900               |
| 1933  | 1,000             |
| 1934  | 1,200             |
| 1935  | 1,650             |
| 1936  | 2,050             |
| 1937  | 2,250             |

Of the last number approximately one-third manufactures fruit juice from customers' fruit.

In England, where apple juice production is in its infancy, one firm with an output of approximately 30,000 gallons per year uses apples costing on the average about £5 per ton. With a yield estimated at 160 gallons to the ton, the cost of the raw material is approximately 7½d. per gallon of juice. This juice is retailed at 6d. per half-pint, or 8s. per gallon, giving a margin between cost of the raw material and the retail price considerably wider than that cited for both U.S.A. and Germany, where, however, the heavy costs of developing a new industry and cultivating new national tastes have no longer to be met.

In this connection it is relevant to remember that one litre of apple juice contains the nutritive equivalent of three pounds of fruit, which yields from 300-380 calories. Expressed in English terms this means that half a pint of apple juice, at present retailed at 6d., contains in a readily available form the nutritive equivalent of approximately one pound of fresh apples.

### C. Regulations

There is one matter upon which there seems to be general agreement in all countries in which the fruit juice industry has already been established, and that is that adequate regulations are essential to ensure that not only are satisfactory standards established for the fruit juices, but also to give to the fruit juice industry the protection from synthetic materials to which it is entitled.

In some continental countries there have been drafted regulations which have been amended and supplemented as found necessary with widening experience, both of the industry and the practical application of the regulations. A very complete and up-to-date set of regulations was published on the 14th September, 1938, in the *Ver kündigungsblatt des Reichsnährstandes* in Berlin (50). A very brief summary of these regulations is here given, but those contemplating the formulation of regulations governing production of fruit juices and related products will be well advised to consult the full text for guidance regarding the matters which it has been found necessary to cover by regulation.

" Fresh fruit juices are juices that are practically free from alcohol intended for immediate use and extracted from fresh unfermented fruit by means of pressure, prepared and rendered capable of keeping according to methods specified below which may be used in a complementary manner.

" (1) By pasteurization.

" (2) By sterile filtration.

" (3) By storing under CO<sub>2</sub> pressure.

" No adulterants may be added. Those specifically forbidden include fruit residues, dried fruit extracts, pressings obtained by adding water to pressed material, chemical preservatives, flavouring substances, dyes, concentrated fruit juices, mineral substances and clarifying agents (except specified exemptions).

" No adulterants whatever may be added to concentrated fruit juices, which must be stabilized by evaporating in vacuo or by freezing. Juices once concentrated may not be diluted again even to their original water content to be called fruit juices, but may only be used for fruit drinks."

The containers are specified, as also are minimum size of bottles. Detailed instructions regarding nature of information to be placed on label are given, emphasis being laid on the necessity of avoiding extravagant and confusing claims regarding the merit of the juice, and on the necessity for showing clearly when the article is a fruit drink or lemonade and not a pure fruit juice.

Similar details are also given regarding fruit syrups and fruit drinks and in conjunction with the above provide a very thorough ruling on all matters affecting the fruit juice industry.

In Holland, Belgium, Switzerland, Canada and England certain regulations are already in force, and in most of these places others are contemplated. It is felt that such regulations drafted by those with practical experience of the industry should do a tremendous

amount to assist in the establishment and maintenance of satisfactory standards of quality, particularly during the initial periods of development.

## **2. Nutritional and medicinal aspects**

### *A. General considerations*

It has long been the concern of those charged with the responsibility of safeguarding the health of the huge masses of people in most civilized countries that industrialization, with consequent changes to urban life, has meant a gradual, but nevertheless steady, decline in general standards of health. It has been claimed that, in general, the urban life has been associated with a reduction in the availability of certain essential foods, and particular emphasis has been placed on fresh fruits and vegetables in this connection. Increasing attention has been given to the reasons why fresh fruits and vegetables play such an important part in satisfactory nutrition of all peoples, but particularly of the young, and of those who, during certain periods, or for special reasons, have additional burdens thrown upon their metabolism.

From medical and nutritional authorities in all countries has come the recommendation that fresh fruits and vegetables form an indispensable part of the nutritional requirements of the peoples. For various reasons, most of which are economic and political, but some of which are technical, it has not been possible to make available at all periods of the year to all classes of the population the requisite amount of fresh fruit and vegetables. Problems of production, storage, transport and distribution, as well as the growth of certain undesirable national practices which tend to make less and less of the family income available for the purchase of these materials, at present render difficult the practical application of the general advice that the nation must "Eat More Fruit". Nevertheless, in view of the fact that not only are fruits and vegetables essential for health, but their liberal use in the diet enables economies to be effected in requirements of fats and concentrates, it is clear that no modern industrialized country can afford to do less than its utmost to bring about the realization of the ideal as quickly as possible.

On the other hand, difficulties in production of fruit of the standard demanded by the consumer, who yearly becomes more discriminating, have meant that greater and greater quantities of fruit, sub-standard in appearance, or outside the sizes desired by the market, but perfectly sound, have become available. Marketing experts are unanimous in declaring that this sub-standard fruit should not be thrown on to the fresh fruit market if gluts and severe depression of prices are to be avoided. It is obvious that a profitable outlet has to be found for this fruit in order to permit the orchardist to meet the rapidly mounting costs of production, and thus make his business of producing fruit an economic proposition.

It is unfortunate in some ways that lack of co-ordination amongst growers in any one country and suicidal competition for markets amongst various countries have resulted in the existence of apparent over-production in certain fruits. In addition, special markets of limited absorptive capacity have been overwhelmed by ill-regulated supplies, and thus the grower has been discouraged in the growth of certain varieties or kinds of fruit.

For these various reasons there is found on the one hand a consuming public advised in the interests of national health to consume more fruit, and on the other large quantities of fruit which cannot be distributed to them in the ordinary way. The necessity of providing adequate solutions to the above problems is fundamentally the reason why such amazing success has attended the efforts of those who have attempted to distribute fruit in a liquid form to the public. Properly treated, the unfermented fruit juices contain practically all of the nutritive and medicinal value of the fresh fruit, and have rightly been termed "liquid fruit".

### *B. Nutritive and therapeutic qualities of fruit juices*

What are the special qualities which make fruit juices so valuable from the nutritional viewpoint?

Briefly the position is that fruit juices which are extracted from fully developed, mature fruit consist largely of water—80-90 per cent.—in which are dissolved or suspended the following materials :—

(1) Starch. This should not bulk largely in fruit juices, because, as the fruit approaches maturity, starch will be hydrolysed to sugars. Nevertheless, it is present to a limited extent in most juices, and will, after hydrolysis, yield supplies of energy. Of special interest, however, is sorbit, which is used in treatment of diabetes, and may indirectly yield to the body supplies of ascorbic acid (48).

(2) Sugars. There are three forms, glucose, fructose and sucrose, all of which, and particularly the former two, are most rapid sources of energy, and are very readily assimilated. Dr. Noorden (73) says: "There is no other food that gives the muscles so rapidly, definitely and directly materials containing energy as the fruit sugars in the juices." The amount of sugar in the original fruit will vary with such factors as soil, seasonal conditions, manurial treatment, variety, state of maturity, and must be regulated to give the necessary sugar : acid ratio which so largely determines palatability of the juice. It is advisable to regulate the sugar content to between 7 and 9 per cent. by weight—a range normal for mature apples.

(3) Organic acids, such as citric, malic, tartaric, which not only influence the flavour and appeal of the juice but exert a stimulating effect on the digestive glands. In addition their presence is believed to assist in preventing undesirable accumulation of certain bases in the alimentary tract. They also serve to protect vitamins from the effect of heat during processing of the juice.

(4) Vitamins in direct proportion to those contained in the parent fruit, and varying with the technique of juice manufacture, the acid content of the fruit and length of storage of the juice. The amount varies considerably in the different juices. Some juices, such as tomato, have liberal supplies of vitamins A, B and C, while other juices show relatively small amounts of one or more of these, and also of G. These are, however, fairly generally distributed throughout the fruits.

(5) Minerals. Most fruit juices have adequate supplies of mineral salts to meet the normal metabolic requirements of the human body. A typical series of apple juices analysed in England showed that potassium, calcium, magnesium, sodium, phosphorus and iron were present (49). Some of these are required only in minute quantities, but others make possible the maintenance of a surplus of bases to assist in neutralizing the  $\text{CO}_2$  in the blood-stream (55).

(6) Tannins, varying in amount and influencing materially the flavour of the juice. Their function in human metabolism is obscure.

Dr. Noorden states (73) that in recommending fruit juices to healthy people the following properties and effects should be carefully considered :—

1. " Their suitability as a *food substitute*, taking into account their considerable nutritive value, which in juices with a high sugar content is equal to that of whole milk and in those with a medium sugar content approximately two-thirds of the milk value. They are especially important for children and adolescents.
2. " They afford an excellent source of *refreshment* of the finest flavour and they can be used for different fruit puddings and ices.
3. " Fruit and fruit juices in food automatically make the body less liable to diarrhoea and similar illnesses. This is particularly important in the case of children and adolescents.
4. " They not only refresh but they also *strengthen* the muscles for those who engage in sport. There is no other food that gives the muscles so rapidly, definitely and directly materials containing energy as the fruit sugars present in the juices. All other foods, even common sugar, need preliminary digestive decomposition.
5. " They *stimulate the bowels*.
6. " They tend to prevent excessive use of alcoholic drinks."

Three properties not mentioned above assist in giving the fruit juices a therapeutic value which has recently been fully appreciated by the medical profession. Mainly negative, these properties are :—

- (1) Relative paucity in albumen.
- (2) Lack of fats.
- (3) Extremely low content of salt ( $\text{NaCl}$ ).

In connection with (1), Heupke (55) states that fruit and fruit juices are valuable in offsetting the high albumen diet of most urban peoples. They also are invaluable in treating cases of inflammation of the kidneys due to the inability of these organs to remove satisfactorily the daily products of decomposition of diets rich in albumen which determines largely the formation of uric acid. By the accumulation of this acid, such maladies as gout are caused.

On the same subject, Noorden (73) writes, "Of the greatest importance . . . is the effect of fruit juices in kidney activity." He also states that they are more efficient than milk and fruit, and superior to the majority of natural minerals or "teas" used for the same purpose. This is especially true in the case of patients suffering with fevers who are inclined to sweat e.g. tubercular patients. Even more striking is the elimination of tiresome sweating in the case of corpulent people when given fruit and fruit juice cures.

*Irrespective of health or disease, or the type of disease, fruit juices form an almost indispensable foodstuff and drink in medical prescriptions aiming at a low salt diet. The most important effects of such a diet are:—*

- (1) Rest for the kidneys.
- (2) Discharge of surplus water from the body since it can accumulate there only in the presence of surplus salt. This is an important function in the case of people with kidney or digestive troubles, excessively fat people and in certain forms of inflammation and wound-healing.
- (3) Resistance to inflammation with both preventive and healing effects. This has been proved in its application to skin and wounds, to mucous membranes associated with tubercle infection, to inflammation of the intestines associated with acute diarrhoea, to catarrh of the stomach, and to inflammation accompanying duodenal or gastric ulcers. They must, however, be used with caution in cases of chronic diarrhoea and when catarrh of the stomach is acute. In the latter case they are most valuable as a preliminary step to building up the diet.

Fruit juices are also valuable, and are widely used on the Continent, in curing liver and gall bladder troubles. The absence of fats, the capacity of eliminating accumulation of water, the antiphlogistic effect of the low salt content, as well as the positive favourable nutritive effect of the fruit sugars are the main reasons for their success.

Gout is another trouble now treated by means of fruit and fruit juices, using these materials to enable the body to free itself of accumulated uric acid. Once relief has been obtained, the observance of days at regular intervals in which the diet is restricted to fruit and fruit juice will prevent recurrence of the trouble.

Heupke (55) draws attention also to the use of fruit and fruit juices in treatment of certain diseases of the heart and system which originate in a digestive disturbance due to accumulation of salt and poverty of bases in the bloodstream.

Similarly, by intelligent use of fruit and fruit juices, blood pressure may be substantially reduced and eventually entirely relieved.

Fruit juices are also of value in conjunction with raw vegetables, as a safe diet for "slimming", providing that discretion be exercised regarding the length of time in which the diet is restricted to these items. The fruit juices provide the necessary energy for the maintenance of strength, while the body yields up its superfluous fat.

Heupke also reports that another disease, called "Heubner Hertesche disease", affecting mainly children in Europe, and involving retardation of development and persistent anæmia, may also be treated successfully by fruit and fruit juices.

In treating diabetes, fruit and fruit juices are now playing a prominent part—a maintenance diet in which glucose and fructose are available without fat and albumen apparently assisting the diabetic to reduce sugar secretion. Where insulin is used, the quantities may be reduced or omitted when "fruit days" are being observed (55).

Some remarkable instances of successful use of fruit and fruit juices in the treatment of chronic asthma are reported from the continent. It is clear that these could only apply to those cases where the asthma has a dietetic origin.

Another disease responding in a remarkable way to treatment with fruit juice is Pink Disease (*Erythrædema Polyneuritica*: Acrodynia). This is a disease of young children of both sexes, characterized by extreme irritability and restlessness, and loss of appetite with consequent loss of weight. In addition there is pronounced intolerance of light and severe muscular weakness, combined with the pink appearance of the extremities from which the disease takes its name. It is associated usually with catarrh of the upper respiratory tract, and with a variety of nervous disturbances accompanied by excessive sweating and desquamation of the skin.

The cause of the disease is still unknown, although it was first described by Swift in Australia in 1914.

It is thought by some to have a dietetic origin, possibly due to deficiency in vitamin, but by others to be due to an unknown infection. As a result, no specific remedy is known, although the condition can be alleviated by certain symptomatic treatment for which careful and skilled nursing is essential.

Several instances have recently come under notice in England in which the children believed to have this disease have been so severely affected by it and associated troubles that they were in children's hospitals under care of specialists who were unable to effect a cure by the methods normally employed. The use of unfermented apple juice in doses regulated to suit the different ages of the children was followed by an immediate improvement in the general condition, which soon enabled them to be discharged from hospital. All children are now reported to be making satisfactory progress to normal health.

It is not suggested that all cases of Pink Disease will similarly respond, but the successful use of apple juice in the cases mentioned indicates that there are potentialities in unfermented juice which the medical profession will not be slow to explore. Not only may it provide a satisfactory remedy for the complaint, but it may suggest a satisfactory explanation for a condition the cause of which has so long been obscure.

Apple juice is one of the few forms of nourishment allowed to patients undergoing the injection treatment for advanced cancer in the various clinics recently established for that purpose in England.

In England recently fruit juice (black currant) has been successfully used and is recommended by prominent medical authorities, for the treatment of duodenal and gastric ulcers.

Black currant juice is relatively rich in vitamin C, having up to 200 mgs. ascorbic acid per 100 g. of expressed juice (28). Syrup made from this juice by the addition of sucrose (27) renders the juice stable. This method not only maintains the vitamin content, but increases the nutritive value of the product because during storage in bulk the sucrose is inverted to fructose and glucose, two sugars readily assimilated.

Black currant syrup is also relatively rich in iron, a typical sample containing 11 parts per million. This syrup can be safely prescribed for patients suffering from ulceration of the intestinal tract, and where a diet is lacking in vitamin C.

Fruit juices are also of great value in the treatment of all cases of inflammation of the lungs, with which is associated fever of varying degrees. One of the big problems in these cases is to nourish the patient sufficiently to maintain strength without increasing the fever. Neusser (71) reports that Dr. Fuhrman in Germany used nothing but fruit juices for the nutrition of 60 such cases without any recourse to heart stimulants. The effect of the juice was invigorating on circulation and general condition, and recovery, after subsidence of the fever, was very quick.

This experience has been checked and confirmed in the general division of the Rudolph-Hess hospital where in all cases of inflammation of the lungs, both children and adults are now given fruit juices almost exclusively. The more active circulation thus obtained has rendered heart stimulants rarely necessary.

Fruit juices are also being used extensively in many countries in sanatoria concerned with the treatment of tuberculosis and other diseases of the respiratory organs.

Properly used, fruit juices are also of value in treatment of nervous disorders. Neusser (71) reports that unfermented fruit juice, especially apple juice, has the most astonishingly soothing effect on the nervous system and that a prominent nerve specialist prescribes fruit juices for all his patients.

In compiling the above list of diseases and illnesses for which fruit and fruit juices have been used very successfully, the authors have been careful to exclude all claims not supported by the necessary medical testimony. It should be mentioned that in many instances fresh fruit and unfermented fruit juices are used in a complementary manner, but medical authorities are in agreement that in most instances when fruit is not available fruit juices may be used entirely alone. This view is well expressed by Heupke (55), who says, "it is a great development that one is not bound to the fruit seasons owing to improvement in preparation of unfermented fruit juices, which enables one to apply fruit cures at any time for any diet". In certain instances Noorden (73) states that fruit juices can be used when fruit would be harmful.

While there is abundant evidence to support the contention that fruit juices are most beneficial to the maintenance of good health and provide a ready means of obtaining a refreshing, palatable and nourishing drink, and while there can be no questioning the fact that fruit juices have remarkable therapeutic value, it is essential to repeat and emphasize the warnings contained in all the writings on the subject.

Fruit juices do not constitute a "cure all" or a magical remedy for all complaints to which the human body is subject. They should be used as medicine only upon the advice of a fully qualified medical practitioner who will prescribe them in the correct proportions and after full consideration of the condition of the patient and of the various delicate dietary problems involved.

It is important, however, to realize that fruit juices must not be assessed simply on their curative powers, remarkable as these have been demonstrated to be. Unfermented fruit juice offer to the public, irrespective of age, sex, or occupation, a most refreshing and palatable series of drinks which can be consumed in moderate quantities at any time during the day and throughout the year with only beneficial results. To those who are quickly using up energy, because of special exertion, fruit juices offer a valuable means of rapidly replenishing nutritional requirements. Athletes, hikers and workmen on the Continent have proved this to be one of the most valuable features of the relatively new drink, for not only is the thirst adequately quenched, but also invigoration is obtained more quickly than from any other source.

There is another aspect of the use of fruit juices which continental experience has shown to be of the greatest importance, and that is their use in connection with pre-natal and post-natal care of mothers. This is quite apart from the value of these juices in providing nourishment and stimulating appetite. The tremendous importance of ensuring that both the bowels and kidneys function properly at this period is a thoroughly accepted principle in medical practice. The value of apple juice particularly in this connection is supported by very complete medical testimony.

Another point of considerable importance from the national point of view is the way in which fruit juices can assist in making milk either more generally palatable, or more readily digested. The nutritive value of milk is universally recognized, but experience in several countries where a scheme for distributing milk in the schools has been tried indicates that, to a proportion of children, milk is most unpalatable, and there is abundant medical evidence to show that to some people milk, being indigestible, is unacceptable. This is quite apart from the necessity of rigorously excluding milk from the diet of those suffering from certain intestinal disorders. This particularly applies to children. Fruit juices can be used in conjunction with milk to make it so palatable that children who hitherto refused to touch milk, eagerly await distribution of their morning supplies. This can be done without any curdling effects (22). Fruit juices can be used, therefore, as a supplement to milk, or as a substitute for it, because it has been shown that pure fruit juice is almost as nutritious as whole milk (71), (73).

Further, fruit juices instead of synthetic materials in the flavouring of ice-cream is a development which may be anticipated in the near future. The added nutritive value as well as the real appeal of the true fruit juices must lead to increased sale of the popular food product.

For young children, too, it has been shown both in America and in Europe that fruit juices have a value from the nutritional point of view which is not fairly represented by their yield of calories and or vitamins. There is something in the complex, in which the fruit sugars, the

fruit acids, minerals and vitamins each play important parts, that is more than the mere summation of the effects of each part separately. It may well be that some factor, such as the increased activation of the digestive juices, or the stimulation given to appetite, or the correction of dietetic unbalance frequently associated with our present assortment of foods, may be of at least equal importance to the other factors mentioned.

It has long been known that certain fruit juices have immense value as a means of preventing the development of unhealthy conditions. The use of citrus juice to prevent scurvy can be mentioned as a simple example of this use of fruit juice, but in the Abyssinian war it was found practicable to eliminate what was regarded as one of the greatest obstacles which the Italian forces were expected to encounter, namely, various diseases associated with camp life in relatively hot regions. Diarrhoea and dysentery and complications from malaria were almost entirely avoided by the use of adequate supplies of fruit and fruit juices. It is generally accepted that the maintenance of morale in an army depends very much on the maintenance of health, and the tremendous importance of fruit juices as offering a means, readily available at all times of the year, of ensuring this can easily be appreciated. It is hoped, however, that the value of the fruit juices in maintaining the health of the nation in peace time will equally well be appreciated, and therefore the importance of adequate supplies of fruit juice in the national economy of each nation sufficiently well recognized to ensure that every encouragement is given by the responsible authorities to the establishment of the industry necessary to supply the fruit juices.

When it is considered that fruit juices represent a readily available form of supplementing the fruit diet, the value of which has long been recognized, that they provide material which can be used without harm by all types of people, and that they have such tremendous value nutritionally and therapeutically, it is clear that national interests can only be adequately served when unfermented fruit juices are readily available in such quantities and in such variety that they may be accessible to all.

## PART II

# TECHNIQUE OF PRODUCTION

### APPLE JUICE

#### 1. Raw material

It was originally considered that apples of the poorest quality could be used for processing, but this idea has been shown to be somewhat untrue. Distinction must be made between fruit which is rejected in the grading room on account of its size or surface condition (i.e. suffering from scab, or fruit which is very large, or small or mis-shapen, etc.) and apples which are definitely commencing to decompose on account of rots, mould growth or actual fermentation. Scab and insect damage do not constitute a serious disadvantage, and the utilization of such fruit enables the apple juice factory to absorb large quantities of fruit which would otherwise be difficult to market through the ordinary channels. It is essential that the bulk of the fruit used should be free from rots and in a sound condition and although some latitude can be allowed in this respect, it is usually fatal to the ultimate quality of the juice to allow more than the very smallest proportion of poor quality fruit to enter the mill. The aim of the producer should be to eliminate entirely any unsound fruit, and only the small amount of unsuitable fruit that escapes mechanical or visible detection can be allowed. All commercially low-grade, sound fruit which is not capable of normal disposal through the usual channels can be accepted in cases where very heavy supplies of certain types of fruit are available.

#### 2. Varietal factors

The ultimate flavour of an apple juice can be regarded as being composed of two separate factors :—

- (a) sugar-acid balance.
- (b) aroma and bouquet.

The juices obtained from various varieties will all differ with respect to both (a) and (b). With the exception of certain outstanding varieties, however, the major differences will be associated with the relative sharpness or sweetness of the juice, whereas the actual apple character is more uniform. In the case of these varieties it is possible to effect a very consistent degree of standardization merely by adjusting the sugar and acid contents of the juice. When this is done they will all possess a common, general character with minor variations in flavour. (An exception to this generalization is the case of the cider apple juices. In this instance the enhanced tannin contents complicate the issue, as the tannin is of extreme importance in conferring "body" and fullness on the juice.) In a few culinary and dessert varieties, however, there is a specific flavour associated with the fruit which is contributed to the juice. Despite this specific character, however, it is seldom possible to identify the fruit from which a given juice has been expressed. For example, the Cox and Laxton characters which are so distinct in the fruit themselves and which account very largely for the superiority of these fruits for dessert purposes, are passed into the juice only to a limited extent. The specific Cox or Laxton character is lost, and attempts to impart this unique flavour to the juices, so that a definite series with distinct characters similar to the fruits themselves could be prepared, have been unsuccessful.

Cider apples have already been referred to. Their importance is limited at the present time owing to the fact that in England the total crop is regularly needed for the existing fermented cider industry, whilst in various parts of the Empire the plantings of cider fruit are still very small and not sufficient to influence the blend to any extent. It is important to note, however, that the incorporation in a blend of culinary or dessert varieties of 10 per cent. cider fruit will

normally have a marked effect on flavour, whilst the use of 20 per cent. will completely alter for the better the character of the finished product. Bittersweet varieties should be chosen for this purpose (i.e. Dabinett, Knotted Kernel, Yarlington Mill, etc.) unless the general character of the local fruit is deficient in acidity in which case some bittersharp varieties should be cultivated.

### 3. Composition of apple juice

From a flavour point of view the most important chemical constituents of fruit juices are the sugars, acids and tannins. The first constituent is usually proportional to the specific gravity of the freshly expressed juice and the following table gives the results of analyses carried out over a series of years at the Long Ashton Research Station with English apples. Many factors, such as soil, manurial and seasonal climatic variations, and the state of maturity of the fruit at the time of milling, influence the chemical composition of the apple, but the data in Table 4 represent an average composition for English fruit.

TABLE 4  
AVERAGE CHEMICAL COMPOSITION OF JUICES OF SOME VARIETIES OF  
ENGLISH-GROWN APPLES

| Variety.                   | Type of Fruit. | Specific Gravity. | Acidity as Malic Acid per cent. | " Tannin " per cent. |
|----------------------------|----------------|-------------------|---------------------------------|----------------------|
| Bramley's Seedling .. ..   | Culinary       | 1.046             | 0.90-1.30                       | 0.12-0.15            |
| Lane's Prince Albert .. .. | "              | 1.045             | 0.87                            | 0.08                 |
| Newton Wonder .. ..        | "              | 1.043             | 0.55                            | 0.08                 |
| Stirling Castle .. ..      | "              | 1.040             | 0.64                            | 0.03                 |
| Wellington .. ..           | "              | 1.043             | 0.90                            | 0.09                 |
| Annie Elizabeth .. ..      | "              | 1.052             | 0.81                            | 0.13                 |
| Edward VII .. ..           | "              | 1.046             | 0.77                            | 0.09                 |
| Cox's Orange Pippin .. ..  | Dessert        | 1.057             | 0.62                            | 0.06                 |
| Laxton's Superb .. ..      | "              | 1.051             | 0.53                            | 0.05                 |
| Allington Pippin .. ..     | "              | 1.048             | 0.70                            | 0.05                 |
| Blenheim Orange .. ..      | "              | 1.051             | 0.53                            | 0.05                 |
| Wealthy .. ..              | "              | 1.040             | 0.70                            | 0.06                 |
| Worcester Pearmain .. ..   | "              | 1.043             | 0.27                            | 0.10                 |
| <i>Vintage :</i>           |                |                   |                                 |                      |
| Kingston Black .. ..       | Cider          | 1.060             | 0.68                            | 0.24                 |
| Foxwhelp .. ..             | "              | 1.048             | 0.70                            | 0.24                 |
| <i>Sharp :</i>             |                |                   |                                 |                      |
| Frederick .. ..            | "              | 1.048             | 1.00                            | 0.09                 |
| Cap of Liberty .. ..       | "              | 1.050             | 0.85                            | 0.22                 |
| Dymock Red .. ..           | "              | 1.052             | 0.55                            | 0.22                 |
| <i>Sweet :</i>             |                |                   |                                 |                      |
| Sweet Alford .. ..         | "              | 1.053             | 0.26                            | 0.14                 |
| Woodbine .. ..             | "              | 1.057             | 0.30                            | 0.16                 |
| <i>Bittersweet :</i>       |                |                   |                                 |                      |
| Knotted Kernel .. ..       | "              | 1.060             | 0.38                            | 0.35                 |
| Dabinett .. ..             | "              | 1.053             | 0.20                            | 0.25                 |
| Yarlington Mill .. ..      | "              | 1.050             | 0.25                            | 0.24                 |
| Medaille d'Or .. ..        | "              | 1.053             | 0.25                            | 0.45                 |

### 4. Blending

Very few varieties are capable of producing juices that are suitably balanced with regard to sweetness and acidity for direct consumption. Culinary fruit are generally too sharp, whilst some dessert fruit and the sweet and bittersweet cider apples lack a sufficiently high acidity for their juices to be acceptable. In this case the various varieties of apples may be blended

according to their several chemical compositions. Blending is a matter of experience, but the main process becomes straightforward when the composition of the various batches of juice is known. In cases where culinary, dessert and cider fruit are available blending produces problems of some nicety, but in general, the matter is confined to a consideration of acidity, and blending is used as a means of achieving some standardization in this constituent. Reference to Table 4 will indicate which varieties are suitable for blending together from this point of view. Blending should preferably be carried out on the fruit where possible, but at any rate juices should be mixed some appreciable time before the product is to be consumed. The mixing of two separate juices often occasions some alteration in condition, and, as in other products, opportunity should be afforded for the various constituents of the blend to "marry together" and for the components to settle down previous or subsequent to the final filtration and bottling.

Whilst it is undoubtedly preferable to subject the juices to chemical analysis to obtain an accurate assessment of their sugar and acid contents, it is possible to make a reasonably satisfactory blend by taste. The personal prejudice of the taster should be carefully controlled and an attempt made to assess the juices from the view point of the consumer rather than from the personal point of view of the person or persons making the flavour test.

## 5. Maturity of fruit

In order that the best possible quality juice may be obtained the fruit should be allowed, where possible, to mature until the flavour and aroma of the apples is fully developed. This maturation of the fruit is not possible when windfall fruit is being milled, as the apples in many cases will commence to decompose before full maturity is reached. Where the varieties are harvested in a sound condition and the fruit is capable of being retained in that condition for a sufficient period to enable maturation to continue, it is advisable to arrange for its suitable storage. Every care should be taken to ensure that the fruit does not develop fermentation or acetification which results in an appreciable heating of the fruit leading to an increased rate of decomposition.

German experience suggests that the fruit should be milled before the fruit is sufficiently ripe for eating purposes.

Whilst it is comparatively simple for fruit growers well acquainted with the various varieties of apples and with their respective behaviour during the maturing period to determine the correct time for the milling process, a useful method employable by factory technicians is associated with the use of iodine to indicate the disappearance of the starch constituent of the apple. Milling should be postponed until the iodine test shows the presence of only small quantities of starch in those portions of the apple associated with the core. Thin slices of apple are immersed in an iodine-potassium iodide solution for two minutes. A blue colour indicates the presence of residual starch in the apple tissue.

## 6. Sorting and washing

According to the condition of the fruit it is necessary either to sort and wash the fruit or merely to wash the apples in one of the machines available for the purpose (Fig. 1). Should the fruit be in poor condition the rotten and badly decomposed specimens must be removed by hand as the fruit passes on moving belts between the sorters. Under ordinary circumstances, however, a thorough washing is sufficient.

The washing process is introduced both to remove from the fruit visible dirt, which would be a source of danger to the flavour of the product, and to reduce the number of micro-organisms on the surface of the apples. Large numbers of organisms passing into the juice prejudice the efficiency of the later processes and the ultimate stability of the beverage.

Washing machines are made in various types. The majority have associated with them a soaking tank into which the fruit is shovelled or tipped and thoroughly agitated. The rotten fruits and those with extensive decomposition and skin damage absorb water and sink to the bottom of the tank and can be removed from time to time through a plug outlet. The fruit floating on the water is then received into one end of a cylindrical vessel whose circumference

is composed of narrow slats of wood separated from each other by spaces  $\frac{3}{4}$  in. wide. A continuous screw is fixed within the cylinder and the whole machine rotates at about 60 r.p. minute. The fruit is gradually rolled forwards and sprays of clean water are directed on the apples throughout their passage through the machine. Many variants of this type exist but are all similar in principle. In some factories, a final washing is effected by arranging a hose pipe over the elevator conveying the fruit from the outlet of the washing machine to the mill. In this case it is essential to allow the fruit sufficient opportunity to drain free from the water. Clean potable water should be used for all washing purposes.

German types of washing machines include a special machine for very dirty fruit. A row of four large, coarse brushes, literally scrub the apples as they are carried forward through the tank.

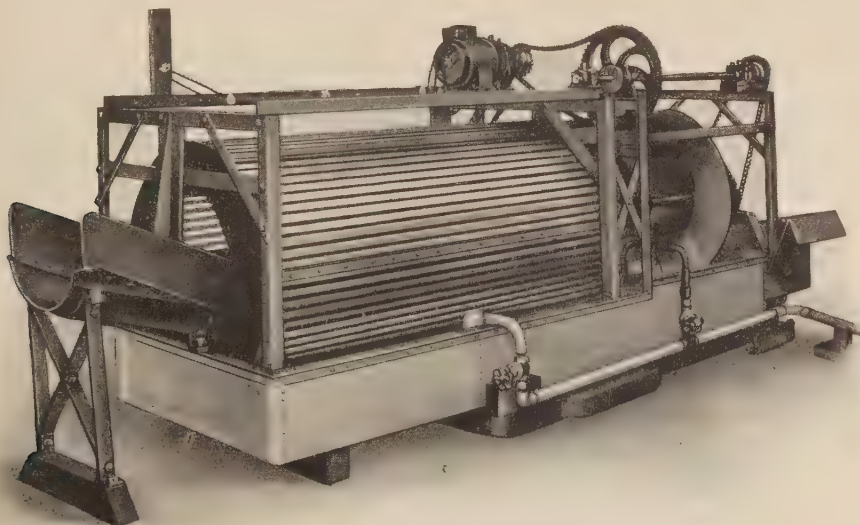


FIG. 1.  
Apple washer (Watts-Adlam type).

## 7. Milling the fruit

In order to obtain the maximum yield of juice it is necessary to disintegrate the fruit tissues and mechanically to disrupt as many of the individual cells as possible to allow a free expression of the juice. The fineness of the division of the tissues is important not only with reference to the fruit cells associated with the flesh of the apple. Mehltitz (66) has pointed out that the concentration of flavouring compounds and vitamins is much greater in the skin and in the region immediately beneath the skin, and that the most thorough disintegration of these portions of the apple is necessary in order to release these important constituents in a soluble form. A grating action has been found to give the finest division, and a fine mush in which the skin is completely disintegrated is obtainable from modern mills. French authorities agree that the finest subdivision of the tissues gives the best quality and yield of juice (35, 84). The old-fashioned stone cider mills, whilst still in use in isolated cases, have now given place to several more effective types of mill which will now be briefly enumerated.

### A. Stone mill

There is still a considerable school of opinion which considers that the old method of crushing the fruit between stone rollers effects the best disruption of the fruit cells. There is

certainly a greater proportion of disintegrated pips obtained from these mills than from other types, but, largely on account of inferior speed of operation, this type of machine is not in wide use in England, although on the Continent there are still many in use, especially in Switzerland.

### B. *Steel mills*

The steel grater or hammer mills have almost completely replaced the more cumbersome and slower stone or wooden mills. They operate at high velocity, are comparatively small machines and are capable of high outputs.

It has not been found necessary to produce mills from stainless steel. During the passage of the fruit through the mill very little metal is acquired by the juice and no ill-effects have been traceable to this source. The new "metallizing" process enables an ordinary steel mill to be sprayed with stainless steel, but a thickness of four thousandths of an inch is needed for a coherent, unremovable layer.

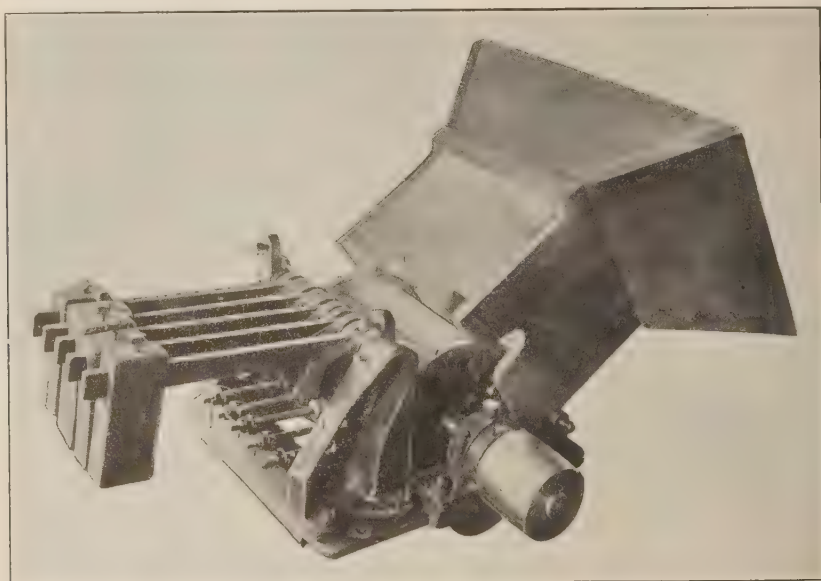


FIG. 2.  
Apple mill (grater type).

(a) Grater mill. This is widely used in English and American cider factories.

A steel cylinder, in which is set a series of serrated knife edges extending about one eighth of an inch above the surface, revolves within a hopper provided with a concave surface adjacent to the knives (Fig. 2). The fruit falls in from above and is cut into a fine pulp by means of these knives. The skin is generally cut into pieces about one inch square, whilst a large number of the pips escape crushing.

There is the possibility that by using this type of mill the pulp will become what is colloquially known as "mealy". This condition is only liable to occur in culinary and dessert fruits which are not yet mature, or more especially when they are over-ripe. The tissue is so finely divided that it forms a sort of "paste" from which it is extremely difficult to express the juice.

(b) Hammer mill. This type of mill has come into prominence and considerable favour in America and Canada in recent years (Fig. 3). The action is quite dissimilar to that of the stone mill. The operation of the mill is by impact and ejection. The raw material is shattered

in mid-air and a fan incorporated in the unit relieves the grinding chamber of the shattered material. The mills are compact and easy to adjust and clean.

(c) German mill. A variation of the above types of mill is recommended by Mehlitz. A spiral screw is associated with an arrangement of short studs rotating on a revolving head. This machine is reminiscent of the earlier form of "picker" mill in which the metal parts were larger and of much cruder design. The new mill can also be used for soft fruits.

## 8. Maceration

Maceration is a very old-established procedure which has been used for centuries in the English and French cider industries (35, 84). The milled fruit is left in the pulped condition for a period varying from 2-24 hours. The reasons for maceration may be briefly enumerated

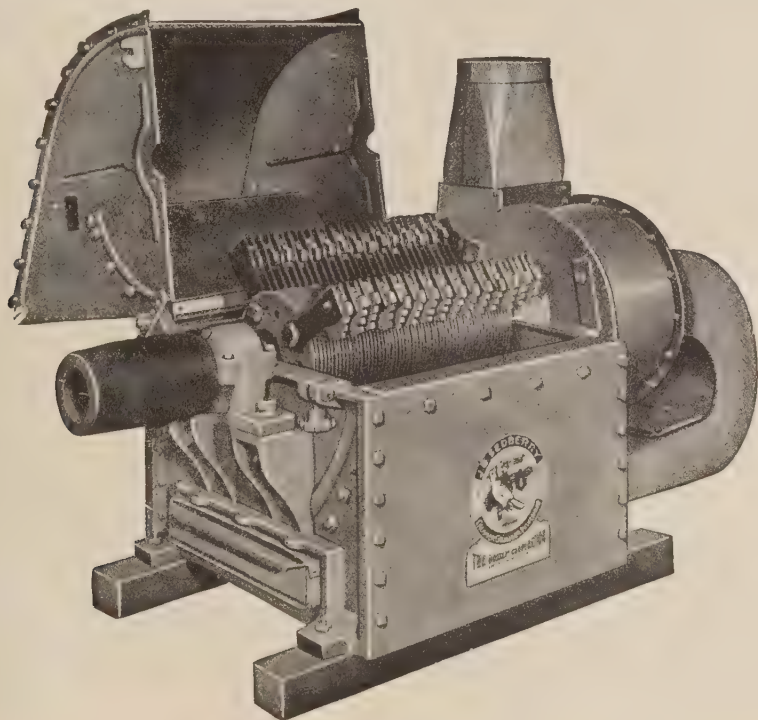


FIG. 3.  
Apple mill (hammer type).

as follows: Maceration (under French conditions for cider-making) often results in increases in flavour, aroma, and colour, together with a better yield of juice. The opponents of the system contend that unless very rigorous control is exerted over the process, maceration is liable to provoke acetification and to remove a certain quantity of tannin with consequent reduction in flavour and colour. Warcollier (84) of the Oenological Institute at Caen, gives it as a considered opinion that maceration should always be carried out, but the process should be as fully controlled as possible to avoid any of the disadvantages that are likely to occur with careless manipulation. Although the inclusion of maceration introduces a further process and its accompanying labour, it should be explained that if facilities are provided for the juice to run away from the shallow maceration tanks there will be a considerable reduction of bulk in the material which will eventually need treatment in the press.

In England maceration has been largely abandoned since the commencement of commercial cider-making on a large scale, but it is still practised very considerably in France. The importance of some form of maceration in the present connection arises from the need to impart to the juice of culinary and dessert apples the fullest possible flavour and character. The earlier products made at Long Ashton indicated certain deficiencies in this respect, and attempts were made to improve the "body" by including the maceration process. The adoption of the ordinary French method did not produce any good result, but on the contrary maceration for twelve hours introduced an unpleasant character. Shorter periods, however, were tried, but the best results were obtained by pressing out the juice immediately the fruit had been

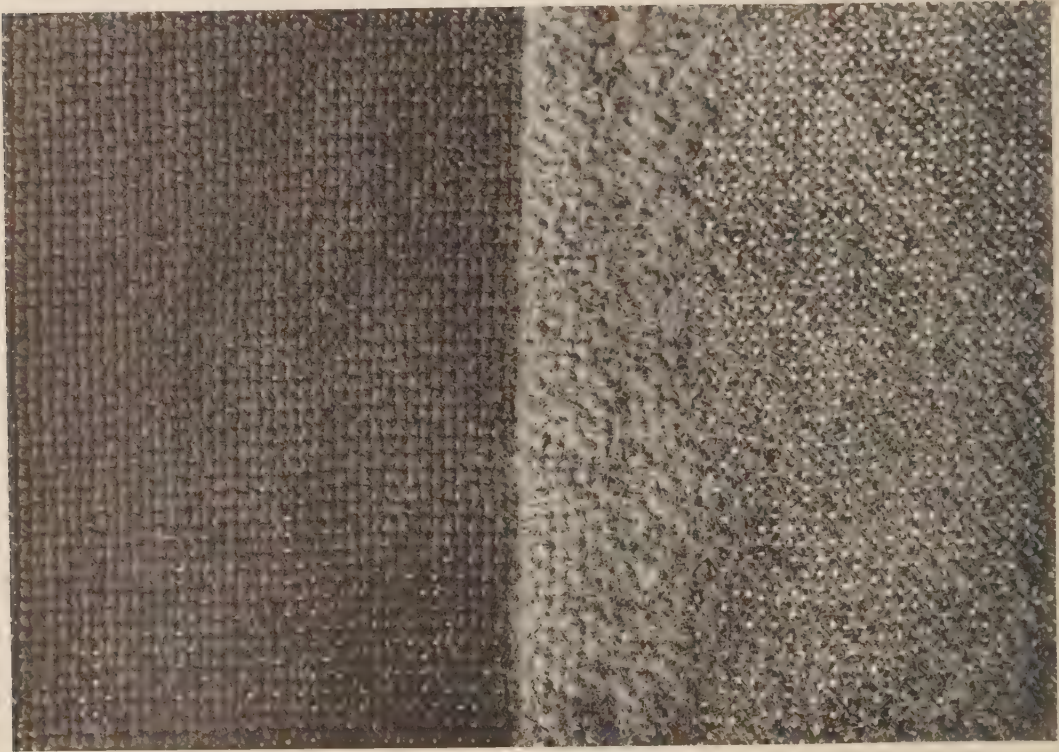


FIG. 4.  
Press cloths (cotton (left) and woollen types after two seasons' use).

milled, and then returning to it a quantity of 35 lbs. of the disintegrated press cake per 100 gallons of juice (30). This should be left overnight. The macerate is then removed either by simple sieving (the solids being added back to the press cloths during the day's pressing) or by means of a rotojector type of centrifuge with continuous discharge of sludge. It is also possible to add the macerate to the juice in a bag of suitable material. This method avoids the sieving or centrifuging processes.

Confirmation of the good results obtained by this modified maceration process has been found by Tiller of New Zealand, working on commercial varieties in the 1938 season.

#### 9. Press cloths and racks

To facilitate the expression of the juice the milled apple pulp is placed on a series of wooden racks in large square cloths which are folded over to form a closed "envelope" to

retain the solid portions of the tissue. The cloths are composed of hemp, cotton or wool. By far the greater number of press cloths are of the cotton type, but many of these have a certain incorporation of Italian hemp of the long fibred variety. The cloths have to resist very heavy pressures and unless the pulp is packed into the cloths with considerable skill excess pressures are caused on account of unevenness in the pack and local breakages in the cloths may occur. The modern cotton cloth, however, is of extremely tough consistency and gives very little trouble except from the point of view of swelling of the fibres. The "openness" of the cloths is of prime importance, as the juice should be allowed to run away freely and yet there should be no appreciable loss of solid tissue through the cloths. As the new cloths become more and more used there is a tendency for the spaces between the fibres to close up, and in poor quality cloths the material may present an absolutely solid appearance. Suitable cloths should therefore be chosen at the outset and due care exercised over their cleaning at regular weekly intervals. Cotton cloths may be boiled for twenty minutes, although the temperature recommended is 180° F. A small dose of  $\text{SO}_2$  may be added before the heat treatment. The cloths should then be dried and given a thorough shaking to remove the dried tissue which is clogging up the pores.

Woollen cloths have recently been examined at Long Ashton and have been found to be very satisfactory for general apple juice and cider pressings. There was no tendency whatever for the cloths to shrink in size or for the spaces between the fibres to become smaller. The cloths remained remarkably soft and pliable throughout a long series of factory tests. Washing of cloths of this type should not be carried out at a temperature above 160° F., but with a very small dose of  $\text{SO}_2$  sterility can be obtained with this limit. Fig. 4 illustrates the difference in the openness of weave in cotton (left) and woollen cloths, photographed after two seasons' use.

Although cotton and woollen cloths are now in almost universal use, it has been reported that car-top canvas and double layers of calico have been used for small scale pressings with success. If the latter method is used the bleach must first be removed by successive boilings in fresh lots of water.

The usual size of racks consists of about 20 slats of wood 46" long  $\times$  2" wide  $\times$   $\frac{1}{4}$ " thick, nailed very closely together on to a similar set of slats placed crosswise. The usual size is 46"  $\times$  46" for a 100-ton press, but all sizes are available to suit the various presses. The formation of the slats is such that the open spaces are only about  $\frac{1}{2}$ " square. The wood needs to be pliable and tough, and to be free from resinous constituents which may impart a flavour to the juice. Ash, willow and white deal are in common use, but high-class racks are made of walnut, which is smooth, easily cleaned and has a long life. The racks should be washed thoroughly each week during the season

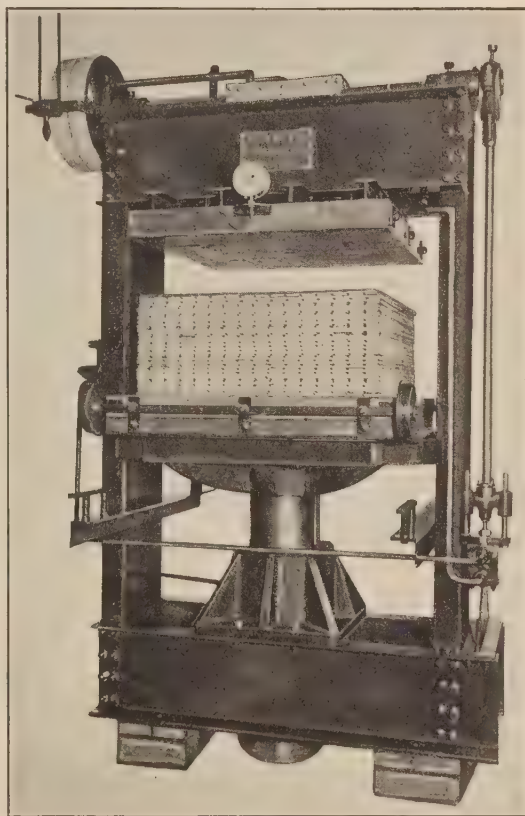


FIG. 5.

Hydraulic press (100-ton pressure, Stowe type).

and when they are to be stored at the end of the making period they should be scrubbed with hot water and then washed with  $\text{SO}_2$  and allowed to dry.

#### 10. Building the "cheese"

The "cheese" is the name given to the stack of cloths which have been filled with pulp and which are separated from each other by the racks.

The bed of the press consists of a fairly deep trough on the bottom of which is placed a rack and a square frame 3" deep to regulate the size of the cheese and the amount of pulp used in each cloth; this is covered with a cloth and pulp is allowed to run in from an extensible chute from the mill (or maceration tank). The tissue is quickly smoothed over to form a level surface and the cloth is carefully folded over at both ends and sides, and a fresh rack placed on top, together with the frame. The process is repeated until 10-15 layers of tissue, each about

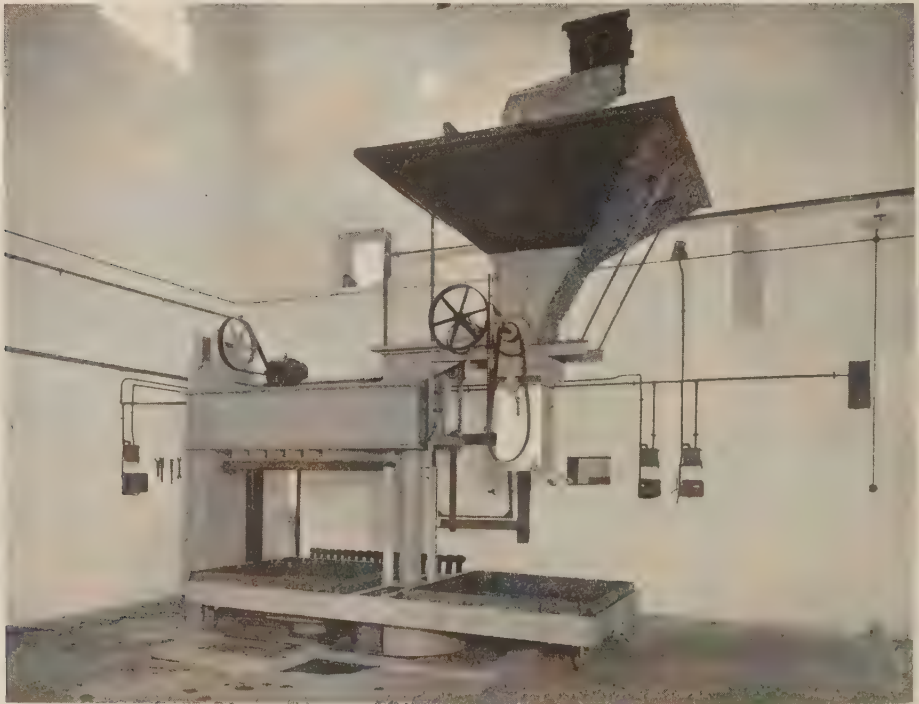


FIG. 6.  
Hydraulic press (German type with turn-table base).

3"-4" thick, are arranged in a vertical formation. The pressure on the top layers is sufficient to express juice from the lower part of the cheese and this collects in the trough around the cheese and is led away to the tanks by reinforced tubing.

#### 11. Transfer of "cheese" to press

Many devices are in use for transferring the stack of racks and layers of apple pulp to the press. It is essential that the press should be very close to the place where the cheese is built, and this being so, the exact method of transference is a matter largely of the nature of the space available. It is necessary to arrange for a system whereby one cheese can be built up simultaneously with the expression of the juice from another. In this way continuity of

milling and pressing is ensured, this effecting a great saving of time and labour. Turntable presses have become popular in recent years and constitute what is probably the most effective type, but with a large press a considerable amount of free space is required both behind and in front of the press itself to enable the steel structure in a press of this type to swing round.

A system of trolleys on rails appears to be adaptable to most conditions, and if two mills are used, then a straight set of rails extending either side of the actual press can be used to maintain a continuous process.

## 12. The hydraulic press and its use

All apple presses are now operated by hydraulic power and are of very similar construction (Figs. 5 and 6). It is becoming a feature of the latest forms of press to arrange for two speeds of operation, a slow commencement followed by a more rapid exertion of pressure towards

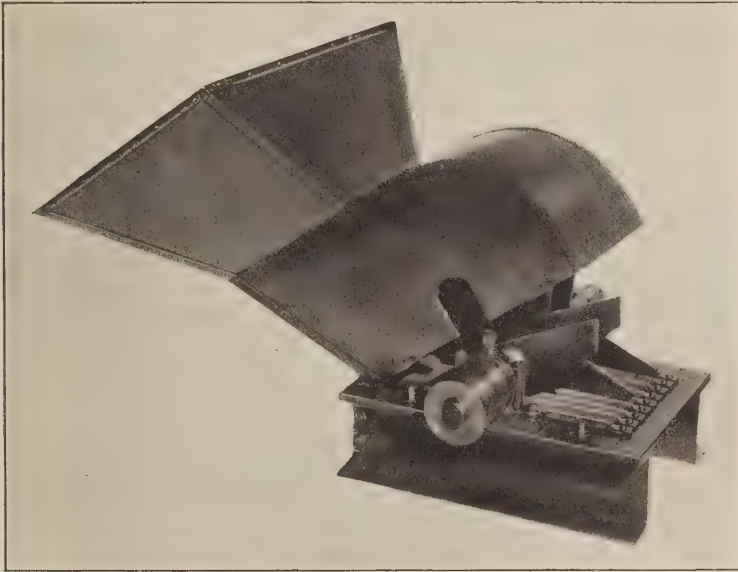


FIG. 7.  
Pomace disintegrator (Stowe type).

the end. The presses are generally made in 100, 175 or 200-ton sizes, i.e. they exert this total pressure on the ram. For a 175-ton press in which the actual area of the cheese is 1,600 square inches, the pressure exerted per square inch of surface is 250 lbs. The gauge fitted to the press usually shows the pressure exerted as lbs. per square inch on the ram. The usual working pressure is a little more than 1 ton per square inch (2,500 lbs. per square inch).

The time occupied in pressing a given quantity of fruit will vary with the size of the press, etc., but a 175-ton press accommodates 1 ton of milled apple pulp and will express the juice therefrom in 30 minutes. Such a machine working during an eight-hour day can press 10 tons of apple pulp.

Various refinements have recently been introduced into presses on the Continent. Mehltz claims definite advantages for a press in which an automatic release of pressure is followed by a reapplication of the pressure—this process being repeated many times. It is considered that the discontinuous action exposes fresh surfaces of the fruit tissue to the pressure of the ram and thus results in an enlarged yield of juice.

In Switzerland it is usual to employ a large press for the first expression of juice and a smaller, very highly powered machine for the second pressing.

In certain cases it is advantageous to press the fruit pulp a second time. To make this process economical it is essential to expose fresh surfaces of the press-cake, and a "pomace disintegrator" or "pomace picker" (Fig. 7) is a convenient machine for this purpose. In design the plant is somewhat similar to the hammer type of mill, and by its use the large slabs of press-cake material are beaten into a fine condition. The pomace is then rebuilt to a cheese, and the juice expressed. In the cider industry, in years of considerable shortage of raw material, a third pressing is sometimes considered to give economical results, but in this case a small quantity of water is mixed with each layer of pomace before going under the press. With normal presses, the average yield that can be expected with three pressings are 150, 20 and 3 gallons of pure juice per ton of fruit. If it is intended to press a second or third time it is not necessary to proceed beyond a certain point in the first pressing.

### 13. Preliminary clarification of the juice

Although there are many methods for the final processing of apple juice, it is usual to effect some clarification of the juice immediately after pressing to remove the solid portions of tissue and to precipitate pectinous and other material which might cause deposits later. Various methods are employed (13, 18, 19, 20, 34, 51, 61, 66, 82, 85).

#### A. *Pectin-decomposing enzymes*

This method is of comparatively recent introduction, but has already become of universal application. The material used consists of a commercial enzyme fixed on to some nutritive base such as bran, pollard or dried corn sugar. The enzyme has been previously secreted from the mycelia of various special types of moulds (i.e. *aspergillus*) which are grown on physiological salt solutions containing sucrose and pectin. In general, 0.1 per cent. (1 lb. per 100 gallons) of enzyme material is stated to clarify apple juice to a sufficient extent in 12 hours at normal temperatures. The centrifuged juice, though not brilliant, is clear and suitable for storage in Boehi pressure tanks (see Section 17a). For some English varieties, however, longer periods are sometimes essential. The use of the enzyme varies with the nature of the subsequent process. If the juice is to be bottled in a brilliant condition directly after filtration, 2 or even 3 days' contact with enzyme is probably necessary at normal temperatures to allow of a complete decomposition of the complex pectins and to prevent any further deposition of solid material after filtration. Where bulk storage under CO<sub>2</sub> pressure is being used, the enzyme can be allowed to continue its work in the tanks, but it is always considered desirable to remove as much as possible of the sludge of fruit tissue before allowing the juices to be stored.

The enzyme appears to act in two ways. Part of the pectin is precipitated as a white flocculent deposit whilst a further fraction is rendered soluble. The course of enzyme action can best be followed by making observations on the viscosity of the juice. An Ostwald viscometer, a stop watch and carefully controlled conditions of temperature are needed for the determination. This becomes important when the juice is being bottled immediately, but in other cases the enzyme can be allowed to act for some arbitrary period, say 24 hours, and the juice then removed from the deposit for storage in bulk.

Temperature has an important effect on the speed of enzyme action, but on account of the increased liability of juices to ferment at temperatures a few degrees above normal, this function of temperature cannot be usefully employed except in special circumstances. Again, the use of increased quantities of enzyme material is a possible means of accelerating pectin removal but the cost is a limiting factor in this instance. It should first be decided whether an absolutely clear juice is needed. If this is so, then the lengthening of the period of reaction is probably the most suitable course to adopt, but it may be necessary to protect the juice from fermentation during this period by a flash pasteurization treatment previous to adding the enzyme.

As a general rule, it is advisable to bring the enzyme into a state of activity immediately prior to its incorporation in the juice. For this purpose the enzyme material should be mixed

with ten times its weight of juice and maintained at about 90°-100° F. for 24 hours. It has been found that this preliminary treatment often saves 12-24 hours on the period of reaction required for the bulk of the fruit material; the juice is thus protected to some degree from fermentation.

For the completion of enzyme action on Bramley's Seedling juice it has been found necessary to allow the juice to remain in contact for 48-60 hours (30). At the end of this time a remarkable clarity was obtained and the filtered, pasteurized juice showed no signs of clouding



FIG. 8.  
Pectin removal by enzyme action (Bramley's Seedling  
apple juice).

after 4 months' incubation or one year's ordinary storage. Fig. 8 illustrates the action of various quantities of enzyme on the Bramley's Seedling juice.

#### B. *Scheidmost*

In Germany, use is sometimes made of the natural material "*Scheidmost*", which is rich in pectin-decomposing enzymes and which is allowed to be added to fresh fruit juices to effect the removal of pectin. Certain varieties of berries in Switzerland are also valued for the same property in their expressed juices.

### C. Gelatin and tannin

This method was until recently in very wide use in Europe and America as a means of pre-clarifying the juice. The tannin solution is added and thoroughly mixed into the bulk of juice, and the gelatin added slowly, the juice being well mixed throughout the addition. The gelatin and tannin are mutually precipitated and the "flocks" that form and slowly settle down through the juice envelop much of the fine material, leaving a juice which is practically clear (Fig. 9). One of the disadvantages of the method is the recovery of the juice from the heavy voluminous deposit, but since the introduction of the centrifuge this has been overcome and the juice can be recovered in a most economical manner. The quantities of the two chemicals that are generally suitable are :

1.5 oz. tannin/100 gallons juice  
2.8 oz. gelatin/100 gallons juice (66).



FIG. 9.

Clarification of apple juice by gelatin and tannin method, using varying amounts of gelatin.

The chemicals should be dissolved in warm water and added to the juice in this form. Care should be taken that the gelatin does not form clumps. The leaf gelatin should be allowed to swell in cold water for one hour before its final solution is effected in warm water. It should be emphasized, however, that the optimum quantities to add are by no means constant and vary with the type of juice. It is advisable to make a preliminary experiment using quantities slightly differing from the doses given above, but on no account should the tannin and gelatin quantities be allowed to become disproportionate to each other, or else there is a considerable danger of one or other of the reagents removing valuable constituents from the juice. Fig. 9 illustrates an experiment in which the tannin addition was unaltered in the four jars on the right, but the addition of gelatin was increased from left to right. The samples marked 2 and 3 have undergone maximum clarification.

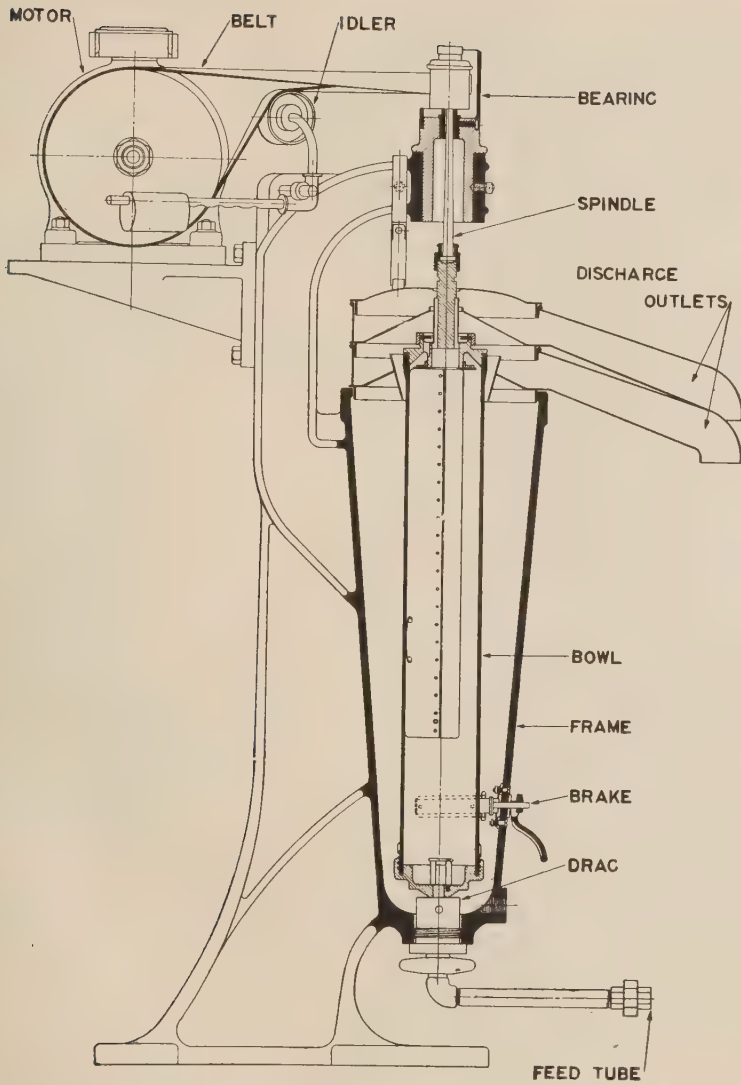


FIG. 10.

Diagram of Sharple's cider centrifugal clarifier for fruit juices.

#### D. *Centrifugation.*

This process has become of the utmost value in apple juice and cider manufacture (10, 19, 32). It is simple to manage and economical in application, despite the relatively high initial cost of the machine. The cleaning of the bowl is easily effected, and some types of centrifuge which are designed to deal with considerable solid contents are fitted with a continuous discharge system whereby intermittent working is obviated. The Sharples (Figs. 10 and 11) and de Laval machines (Fig. 12) are made of metals which are suitable for apple juice.

The centrifuge is a very valuable aid to filtration. Apple juice, cider and soft fruit juices are often extremely difficult to filter to a brilliant condition at a suitable speed on account of the fineness of the deposit. The centrifuge is able to increase the output of a pulp filter by 300-400% by virtue of the removal of the tissues which would clog up the pores of the filter pulp.

It has not yet been found possible to obtain a perfectly clear juice from the centrifuge and consequently some form of "polishing" filtration is always necessary.

#### E. *Filtration*

In certain cases it may be necessary to supplement one of the foregoing methods by a filtration which, whilst it will not yield a brilliant juice, will result in a more complete clarification. This effect is given by asbestos gravitational filters, or by loosely packed pulp filters, which are discussed later in Section 16. Pulp filtration of apple juice should always be preceded by one or other of the above methods for clarification, in order to prolong to the fullest extent the effective life of the filter packing. The centrifuge is an extremely useful adjunct to the pulp filter and for the processing of large quantities of juice this machine should always be used in association with the filter.

### 14. **Chemical adjustment of juice**

The chemical adjustment of apple juice, even when carried out with care, is liable to lead to some impairment of quality, either immediately or only after a term of storage. Blending of fruits or juices is the best method of arriving at the required composition in the juice or of standardizing large bulks made from various consignments of fruit of different sorts. However, standardization of flavour by blending can only be effectively carried out if a sufficient number of varieties is available with a reasonably wide variation in composition. For example, no useful blending can be done by mixing Bramley's Seedling, Lane's Prince Albert, Newton Wonder and Wellington varieties together. These are all sharp varieties and it is essential to obtain some sort of low-acid fruit such as Worcester Pearmain or cider fruit to form an effective blend. Again, some juices blend well together whilst others do not "marry" and it is a matter of considerable experience to be able to make the best use of a given number of different juices. It is necessary to avoid the use of any bulk of juice which is inferior in quality lest the whole blend suffer in respect to general quality.

Conditions in various countries differ with respect to the quantities of sharp and sub-acid apples available for processing, but, where there is a large surplus of the former sorts, chemical adjustment of acidity is a necessity.

#### A. *Reducing acidity*

The most usual adjustment is the reduction of the acidity to a figure in the range of 0.5-0.75% malic acid. This is effected by the addition of regulated quantities either of pure precipitated calcium carbonate (chalk) or potassium carbonate. There is a slight preference in favour of the latter compound, as chalk may contribute a slight "earthy" taste if an excess is left too long in contact with the juice. The usual amount to add to sharp, culinary apple juice is 2-2½ lbs. per 100 gallons, and in view of the severe frothing which occurs, it is necessary to add the chalk to the juice in vessels which are not more than three-quarters full. The chalk acts very quickly but sometimes a precipitate of calcium malate is slowly deposited. The juice should be racked away from any such material after it is seen that interaction between the fruit acids and the chalk has ceased. In this way it is possible to reduce the acidity of a juice from



FIG. 11.  
Fruit juice centrifuge (Sharples' type).

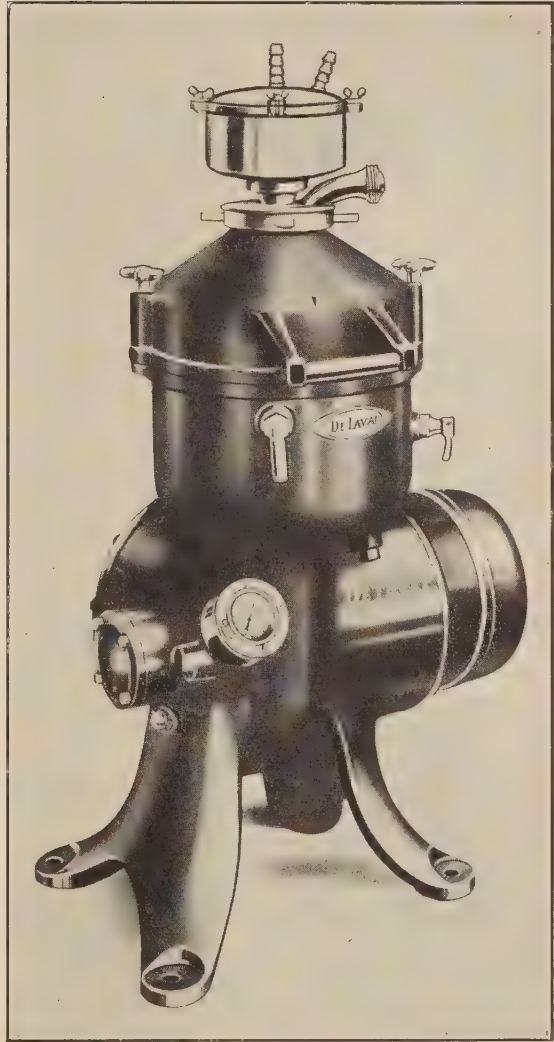


FIG. 12.  
Fruit juice clarifier (de Laval type).

1.2% to 0.75% without any ill-effects, thus making it possible to use sharp varieties alone to produce a beverage with an acceptable sugar-acid balance (30).

### B. *Raising acidity*

Some cases may occur when, for various reasons, an insufficiency of acidity is present, and no sharp juice for blending is available. Very few English varieties exist in which the acidity is too low, but some Empire varieties are sub-acid and might need adjustment. The essential concern should be to add a pure fruit acid. Of these, citric, tartaric and malic acids are available. All three acids give different flavour effects, e.g. citric acid provides a penetrating, refreshing acidity with a definite "lemonade" character; tartaric acid is refreshing without the excessive sharpness of citric acid; malic acid gives the softest acid character of the three, and the addition of this acid to apple juice cannot be detected by tasting. Of the three products, tartaric acid is probably the best suited to normal requirements. It should be dissolved in hot water (8 lbs./1 gallon water) and boiled for a few minutes. On cooling, the requisite quantity should be stirred into the juice with every care, agitating the juice efficiently the whole time and pouring in the concentrated acid solution in a fine stream. The solution is so dense that it would otherwise immediately sink to the bottom and be blended only with difficulty.

If the juices are being standardized at a certain acidity, the amount of acid to add can be calculated when the acidity of the sub-acid juice is known. The addition of one pound of any of the above mentioned acids per 100 gallons of juice raises the acidity by 0.10%. Consequently, if it is necessary to raise the acidity by 0.25%,  $2\frac{1}{2}$  lbs. of acid will be needed per 100 gallons of juice.

### C. *Increasing sweetness*

In Europe, high acidities are sometimes masked by raising the sugar content. The importance of arriving at the optimum sugar content will be stressed later, but if it is eventually considered that the sweetness (as indicated by a specific gravity determination) needs increasing, this can be carried out by the addition to the juice of a cane sugar syrup (10 lbs. sugar/1 gallon water) which has been boiled for half an hour, skimmed and stored in a clean cask. The sterilization of the syrup by boiling is important for ordinary white sugar from sacks is by no means sterile. Here again, mixing should be efficiently carried out, on account of the very heavy nature of the syrup to be added.

The adjustments mentioned above should generally be carried out after the initial processing and enzyme action but previous to filtration. Fresh juices with the accompanying tissue should never be tasted for the purpose of adjusting the sugar-acid balance. It should be remembered that the character of the juice may be altered by the removal of the pectin and other materials, and hence the taste of the juice will not give a reliable guide until it is in an almost clear (i.e. centrifuged or filtered) condition.

## 15. *Deaeration.*

The extreme importance of deaeration as a means of preventing changes and loss of flavour in citrus juices was first established by Cruess and Joslyn working in the Fruit Products Laboratory at Berkeley, California (30, 58, 59, 60, 64, 65). The work was extended to other fruit juices and similar results were obtained. It is believed that the effect of deaeration is to inhibit the activity of plant oxidases which pass through into the juice and are reputed to be responsible for many alterations in flavour and in some cases for a slow, steady reduction in intensity in the flavouring constituents. The presence in the apple of oxidase materials of some kind is indicated by the browning of apple tissue exposed to the air, as well as by certain colour phenomena which occur in freshly expressed apple juice. Consequently there is the possibility that oxidase activity may be responsible for some detrimental changes in flavour. If this be so, the position becomes more serious when long term storage is involved, especially when it is desired to make full use of a large surplus of fruit occasioned by a glut of apples, and to store juice for perhaps two years. It is probable that deaeration is not so important in juices which are stored under high  $\text{CO}_2$  pressures, but, on the other hand, juices which are filtered into bottles by the cold process will not be similarly protected against oxidase action.



FIG. 13.

Deaerator for fruit juices (Aluminium Plant & Vessel Co. patented type).



FIG. 14.

Fruit juice pulp filter (Adlam's Karl Kiefer type with "Tetley" patent pressure equalizing head).

A further point of importance in connection with deaeration is that there appears to be a definite improvement in flavour in the pasteurized apple juices if deaeration is carried out immediately prior to the heat treatment. The use of this treatment for apple juice has been recently described in a communication by Charley (30).

Commercial deaerators are based on the principle of allowing the juice to flow in a thin film over a very large area which is in contact with a high vacuum (25"-27"). The juice can be sprayed through a jet into a spherical vessel in such a way that it runs down the walls or over symmetrical flanges to give a cascade effect, and becomes deaerated during its passage. Many different forms are available but the above fundamental principle is employed in each.

An adaptation of a cream deaerator (Fig. 13) has been used at Long Ashton at a lower vacuum (15"-20") but the juice was heated to 100° F. previous to being deaerated (*Long Ashton Annual Report, 1938*, in course of preparation). The removal of the juice from the deaerating vessel is more easily accomplished if the juice is not heated, and if the vacuum is maintained at 25"-27".

The machine illustrated in Fig. 13 shows the interior plates removed from the stainless steel vessel.

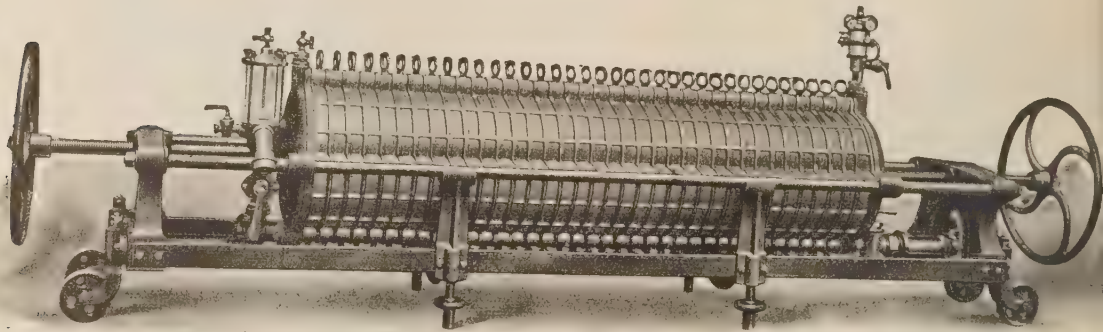


FIG. 15.

Fruit juice and cider filter (Adlam's Invicta type for single and double filtration).

## 16. Final clarification

The complete clarification of apple juice is effected by various forms of filters, but in every case it is an advantage to pass the juice through a centrifuge prior to its filtration. When enzyme or other preliminary clarifying processes have been adopted, the centrifuged juice can be filtered to a brilliant condition with ease.

For the cold process, a slightly cloudy juice that has been centrifuged after enzyme or other action is suitable for storage in pressure tanks, but absolute clarity is essential in those juices that are to be stored by the hot process either in bottles, or glass jars or in tanks. Three forms of filter are available for this purpose.

### A. Pulp filter. (Types: Adlam, Briggs, Karl Kiefer, Stowe)

These filters, which will provide a brilliant but generally an unsterile juice, make use of specially prepared cotton and asbestos pulp which is either packed tightly into the filter in a wet condition, or is pressed into hard cakes which are then placed between steel plates in the filter press (Figs. 14, 15 and 16). For large scale operations, the latter method is preferable. The juice issuing from the filter reaches the true gravity in a much shorter space of time than when wet pulp is used, and again, the packing of large filters with wet pulp by hand is a time-consuming operation and liable to cause serious trouble unless skilled labour is available.

In either case, washing machines are essential for cleaning the pulp when it has become clogged with micro-organisms and apple tissue (Fig. 17). The washing machine is designed to wash out the yeasts, etc., and, equally important, to beat the pulp very efficiently to prevent the formation of "knots" from the long strands, in which form the pulp originally exists. When "knot" formation becomes appreciable it is impossible to pack the filter efficiently, and unsatisfactory filtration results.

#### B. Plate and frame filter

This filter (Fig. 18) is widely used in the sugar industry and obviates the use of any pulp-washing plant. The method consists in the filtration of juice through a layer of diatomaceous earth of special purity. The diatoms occur as a marine deposit in a range of Californian hills and are chemically treated with solvents and finally calcined to remove any possibility of imparting an extraneous taste to the juice. The filter-aid is laid down in a coherent layer on large sheets of filter cloth (Palma twill) which are supported on vertical wooden surfaces separated by thin, hollow frames round the periphery of the filter. Some filter-aid is also mixed into the cloudy juice, and a cake of the material, in which is retained the solid portion of the juice, is built up within the hollow frames. The method is efficient and gives very good results with apple juice. The diatomaceous earth or kieselguhr filter has been adopted to a considerable extent in Germany for filtration of juices immediately previous to their reception in Boehi tanks.

#### C. Filter discs

Clarification of apple juice that has received some degree of pre-treatment is possible by the use of compressed filter discs such as the British-made Sterilmats or the Seitz K. or AW2 sheets. These pads should not be expected to effect any considerable removal of solid material, but very good results are obtainable on centrifuged juices. The paper pulp used for the pad is also available in a block form for mixing with water into a pulp which is spread over gauze to form a gravitational filter.



FIG. 16.

Press for compressing filter cakes for Invicta type filters.

## 17. Storage

Apple juice is an extremely fermentable product. It has been shown that the liability to ferment is greater in cooking apple juices than in cider apple juices on account of their higher nitrogen content which is caused by the special cultivation and manurial methods adopted for market varieties. Again, fresh apple juice is much more fermentable than cider. In the

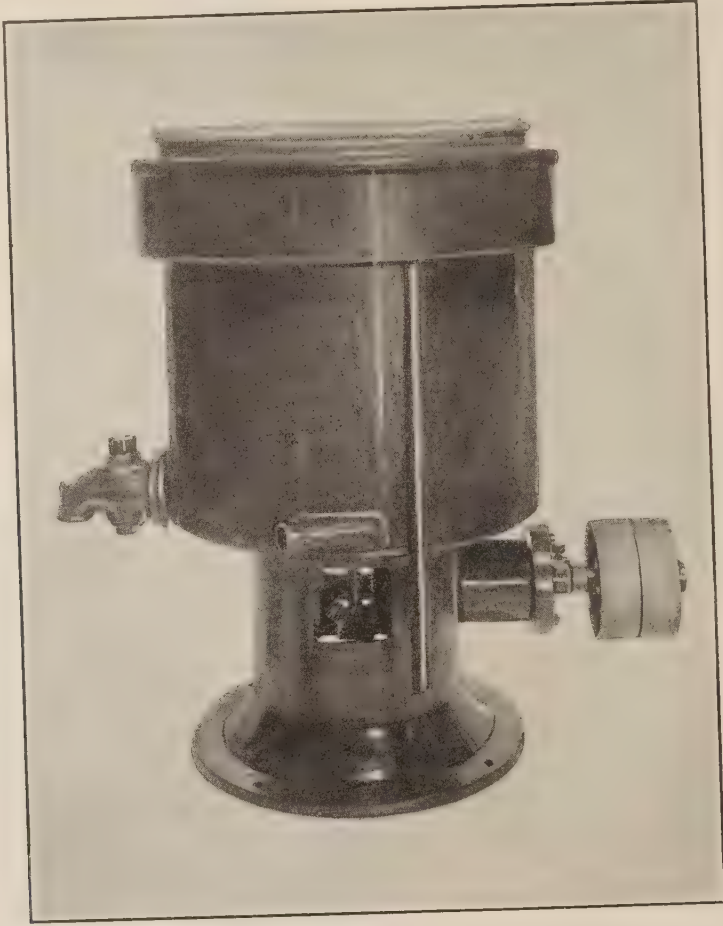


FIG. 17.  
Pulp washer (Stowe type).

latter product, a very large proportion of the nitrogen compounds which act as yeast nutrients (and consequently are necessary for the growth and development of the micro-organisms) has been removed in the metabolism of the yeast cells themselves by the centrifugation or filtration process, and the stabilized ciders are consequently starved of this particular yeast food. In the unfermented juices the complete supplies of nitrogenous and other assimilable yeast foods are present in the juice, and for this reason the processing of the juices must be regarded as needing the utmost care and attention. Because of the above considerations the safe storage of large bulks of unfermented apple juice presents a much more serious problem than that of cider.

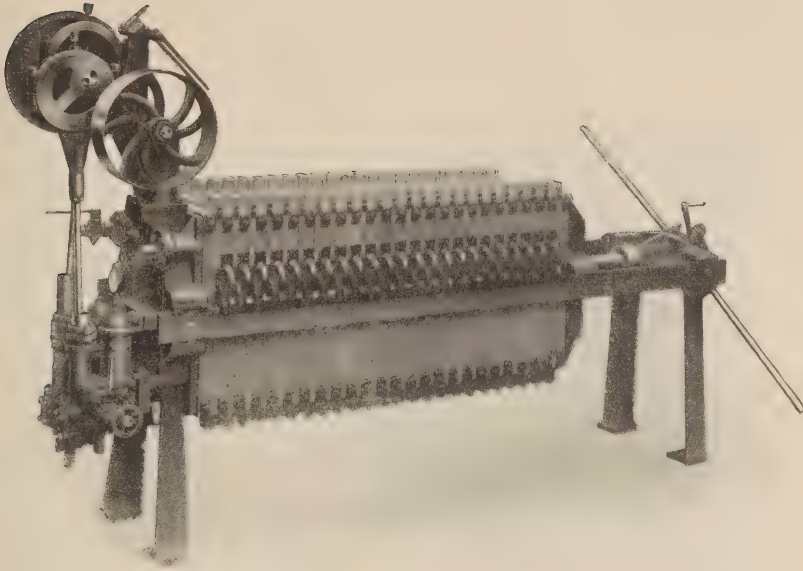


FIG. 18.

Plate and frame filter (S. H. Johnson type with self-contained belt-driven feed pump).

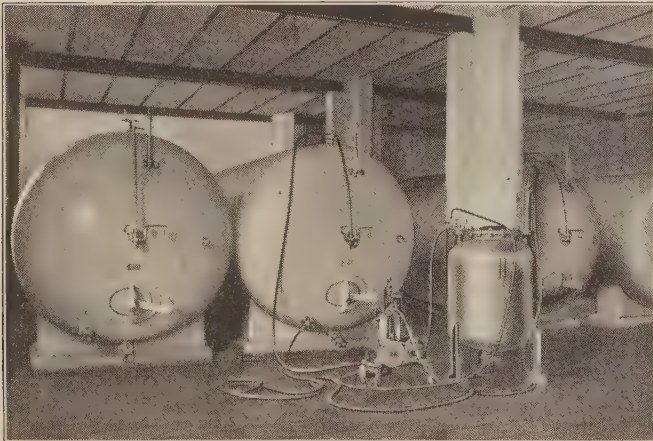


FIG. 19.

Boehi pressure tanks for storage of fruit juices under  $\text{CO}_2$  pressure.

Juices to be stored must either be sterilized by some method and maintained in this condition of absolute sterility throughout the storage period, or alternatively the development and propagation of the yeast population remaining in the juice must be continuously suppressed. The most satisfactory method yet devised for securing the latter involves the impregnation of the juice with a heavy pressure of  $\text{CO}_2$  and its storage in steel tanks with the inside surface coated or lined with some material impervious to apple juice.



FIG. 20.  
Impregnating pump for use with Boehi tanks  
(Seitz type).

#### A. Cold process

##### (a) Boehi pressure tanks

This process originated from an observation of Professor Boehi (Switzerland) in 1912 that fermentation in fruit juices could be prevented by impregnating the juices with  $\text{CO}_2$  at a pressure of 120 lbs./square inch. In the present form of apparatus the juice is stored in large steel tanks tested up to 20 atmospheres pressure (Fig. 19) and coated inside with stove enamel (8-fold application process) or with the more usual linings such as Ebon, Gaschell and Pfaudler. Lithocote, a recent introduction, has been satisfactorily employed for fruit material in U.S.A., whilst Bakelite linings are suggested by Mehlitz as being easily capable of repair. In commercial factories, the tanks are usually 5-10,000 gallons capacity and are sold with various fittings which enable their contents to be pumped, under pressure, from one tank to another. Suitable manholes, fitted flush with the bottom of the tank, are necessary for the efficient cleaning of the inner surfaces. With this form of storage the absolute sterility of the tank is not so important, as the juice will merely have been passed through a gravitational asbestos filter or centrifuged, and consequently will contain a large number of yeast cells. The surface

can be sterilized by steam and washed over with sterile water. The tank is then filled with water to remove the air, and the water replaced by  $\text{CO}_2$  under a pressure of 120 lbs. square inch. The juice is passed through a special pump (Fig. 20) which forces it into the tank and thoroughly impregnates the juice with a high content of  $\text{CO}_2$ . It is also possible to use a centrifuge of special construction (Fig. 21) which removes the solid portions of the tissue in the usual way, but in addition impregnates the  $\text{CO}_2$  into the juice and delivers the juice into the tanks under the required pressure of gas. Provided the required pressure of  $\text{CO}_2$  is maintained, complete inactivation of micro-organisms is achieved.

In 1937 solid carbon dioxide was used in Germany in place of the cylinders of gas for the provision of the gas pressure in the tank. The cheaper price for the solid product was such that recovery of  $\text{CO}_2$  after storage (mentioned later in this section) was not thought to be

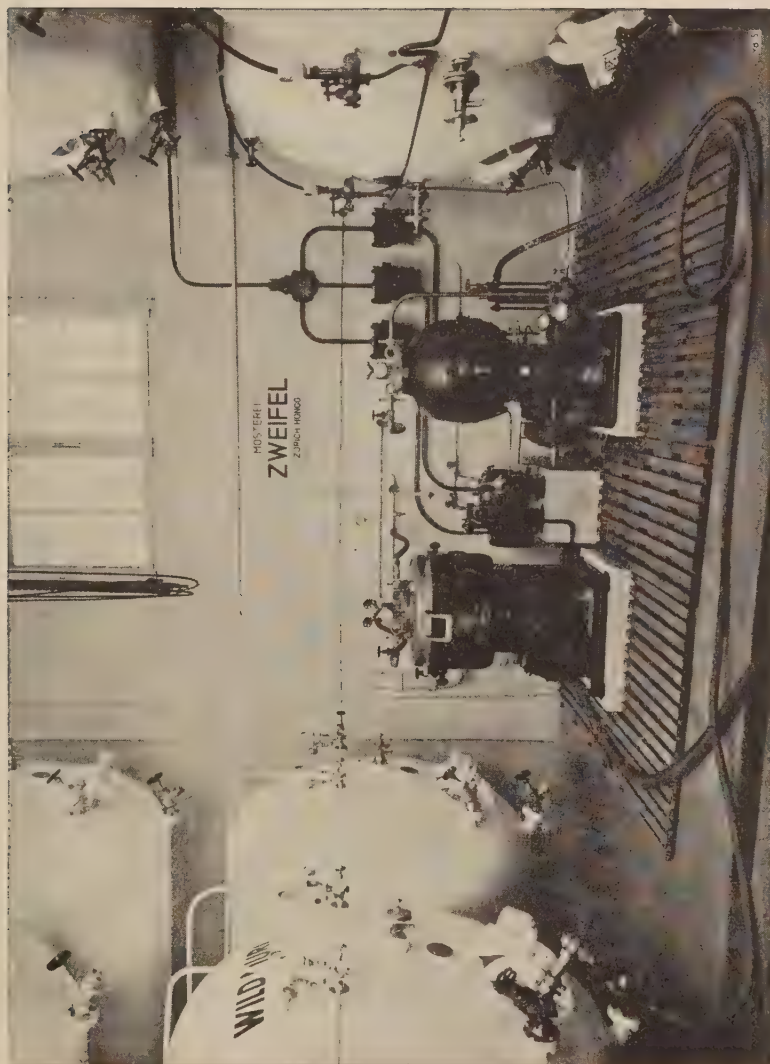


Fig. 21.  
Pressure tanks and associated plant (de Laval FD.12 Pre-clarifier and de Laval  
FD.5 high pressure clarifier complete with  $\text{CO}_2$  impregnating device).

necessary. For a tank of 2,200 gallons capacity 660 lbs. of dry ice is placed in the tank and covered with 100 gallons of water. The air and water are removed from the tank by the gas pressure of the evolved  $\text{CO}_2$  and the tank is then closed and the pressure allowed to rise to the necessary figure.

Too great reliance should not be placed on the precise figure of 120 lbs.  $\text{CO}_2$  /square inch. Temperature effects have a considerable influence on the amount of  $\text{CO}_2$  actually remaining in the juice, and the stability of the juice can only be considered to be adequately safeguarded under all conditions of temperature, etc., when it contains  $\text{CO}_2$  to the extent of  $1\frac{1}{2}$  kgs. of  $\text{CO}_2$  per hectolitre (315 lbs./100 gallons). When the tank is completely filled with gas the analysis of the gas should show the presence of not more than 2 per cent. of oxygen.

It is desirable that the tanks should be kept at reasonably low temperatures,  $10^\circ\text{--}12^\circ\text{C}$ . being quite satisfactory, whilst  $15^\circ\text{C}$ . should be considered as the absolute maximum. At the  $10^\circ\text{C}$ . storage temperature the total pressure of  $\text{CO}_2$  in the juice can safely be lowered to  $6\frac{1}{2}$  atmospheres.

The recovery of the  $\text{CO}_2$  when a tank is opened for bottling purposes is now achieved by the use of a compressor pump which refills the  $\text{CO}_2$  cylinders for further use. There is, however, a gradual loss of  $\text{CO}_2$  due to leakage and other causes, but in an up-to-date installation this loss is of minor importance as far as cost is concerned.

#### (b) Cask storage

The storage of cold processed, clarified apple juice in any vessel other than a Boehi pressure tank is accompanied by certain definite risks. Sterility of the juice must be effected by a sterilizing filter, such as the Seitz E.K. type, the filtering discs of which are of such a composition that the passage of yeasts and bacteria is prevented. It is interesting to note that the filter does not act entirely as a sieve, for although it will quantitatively remove bacteria only  $1\mu$  in size, some of the pore spaces of the pads have been calculated as being  $17\mu$  in diameter (16). It is probable that absorption phenomena are associated with the action of the cotton-asbestos mixture. The filter has now been in use for fifteen years, during ten of which it has been in extensive use in English cider factories, where its inclusion in the manufacturing procedure has caused a complete revolution in cider-making practice. Until quite recently there has been no filter disc with a comparable performance on the market, although in 1938 English pads for which sterilizing powers were claimed were introduced. Limited tests at Long Ashton appear to indicate that the claim regarding Sterilmats are justified.

The use of the sterilizing filter must be accompanied by certain precautions which must never be omitted. The whole filter, when fitted with pads, is steamed until every outlet becomes too hot to touch by hand. Cold water is pumped through to remove the "asbestos" taste from the discs and until the metal surface becomes cool. The filter is then ready for use. With such a fine texture in the pads, it is obvious that they must not be given any duty to perform such as removing actual solid tissues or other materials the sole function being to sterilize the juice by removal of yeasts and bacteria; hence, only bright juices should be allowed to enter the filter. This prolongs the life of the pads and minimizes the chance of straining them by filtering at too high a pressure. The pads are useless when once the pressure has been built up beyond the limit of 22.5 lbs./square inch. Certain types of filter are designed to work at high pressures, but in these cases the pressure difference across the pads must not be greater than the stated figure.

The difficulties in obtaining a sterile juice are of a very minor order when compared with the problems of maintaining the filtered juice in a sterile condition. From the outlet of the sterilizing filter it is essential that all surfaces or air that come in contact with the juice should be absolutely sterile. Storage vessels that do not comply with this condition are therefore quite useless.

In Germany a considerable stock of apple juice is stored in large oval vats (2,000 gallons) or in smaller 100-gallon casks. These are sterilized by means of the injection into the vats or casks of  $\text{SO}_2$  from a liquid  $\text{SO}_2$  machine (sulphitometer), which allows measured quantities of the gas to escape into the vessels. The casks are sealed and allowed to stand for a few hours (preferably overnight), the  $\text{SO}_2$  is removed by washing out with sterile water, after which the



FIG. 22.  
Method of filling casks for cold process storage.

juice from the sterilizing filter is received into the cask by a special fitment to prevent access of air. Fig. 22 shows the type which was made at Long Ashton according to German practice.

Charley (30) has examined the use of this method of storage on Seitz E.K. filtered culinary apple juice in which 25% of cider juice was incorporated. In view of the very scanty published data on this matter the figures obtained from these experiments are given in Table 5.

TABLE 5  
STORAGE OF STERILE APPLE JUICE IN WOODEN AND METAL VESSELS  
(Original Gravity of Juice, 1.045)

| No. | Type of storage vessel.            | Treatment of vessel.                                                       | Specific Gravity of juice after 12 months. | Condition of juice after 12 months' storage.                                    |
|-----|------------------------------------|----------------------------------------------------------------------------|--------------------------------------------|---------------------------------------------------------------------------------|
| A   | Cider cask.                        | Steamed 1 hour: treated with 1 gallon calcium bisulphite for 1 hour.       | 1.037                                      | Cloudy: considerable evaporation: surface covered with vinegar plant and mould. |
| B   | "                                  | Treated with 40 c.c. liquid SO <sub>2</sub> for 24 hours.                  | 1.038                                      | Cloudy: some mould on surface.                                                  |
| C   | "                                  | Treated with 40 c.c. liquid SO <sub>2</sub> for 24 hours.                  | 1.031                                      | Brilliantly clear liquor: mould on surface.                                     |
| D   | Beer cask.                         | Dukeron lining: treated with 1 gallon bisulphite for 1 hour.               | 1.018                                      | Slight haze: mould on surface.                                                  |
| E   | Cider cask.                        | Bottomley cask enamel lining: treated with 1 gallon bisulphite for 1 hour. | 1.041                                      | Clear juice: very thick film of mould: juice of good flavour.                   |
| F   | "                                  | Nobel cask enamel lining: treated with 1 gallon bisulphite for 1 hour.     | 1.028                                      | Brilliant juice: very slight vinegar and mould film.                            |
| G.1 | "                                  | Dukeron lining: treated with 30 c.c. liquid SO <sub>2</sub> for 60 hours.  | 1.042                                      | Cloudy juice: some mould.                                                       |
| G.3 | "                                  | Dukeron lining: treated with 30 c.c. liquid SO <sub>2</sub> for 60 hours.  | 1.018                                      | Very cloudy: thick film of mould.                                               |
| H   | Beer cask.                         | Treated with 40 c.c. liquid SO <sub>2</sub> for 4 hours.                   | 1.000                                      | Cloudy juice: slight vinegar film.                                              |
| J   | "                                  | Treated with 40 c.c. liquid SO <sub>2</sub> for 12 hours.                  | 1.003                                      | Clear juice: slight vinegar film.                                               |
| K   | Metal cask (lacquered) 10 gallons. | Treated with 1 quart 2% SO <sub>2</sub> for 6 hours.                       | 1.033                                      | Brilliant but very dark coloured juice: metallic taste.                         |
| L   | "                                  | Treated with 1 quart 2% SO <sub>2</sub> for 6 hours.                       | 1.045                                      | Brilliant juice: lighter colour than K: very slight metal taste.                |
| M   | Stainless steel (5 gallons).       | Treated with 1 pint 2% SO <sub>2</sub> for 6 hours.                        | 1.042                                      | Clear: clean attractive flavour: no metal taste.                                |

The reason for the greater reliability in the German procedure appears to be that the casks and vats are specially made for the purpose and are constructed of very thick, well-seasoned oak. The casks are trussed with an elaborate series of strong hoops and are permanently fitted with a special bung to which can be attached, in the case of the larger vats, an air filter to sterilize any air that may gain access to the juice. As a general rule, however, cold processed juice is not stored in ordinary, unlined, wooden vessels.

A certain proportion of casks are now being lined with bituminous and other forms of linings such as Ebon and Gaschell (Swiss), Dukeron, Bottomley's Brown Cask Enamel, and Nobel cask lining (British), Etanchit (French) and Mamut-Ventur (German). Some of these materials need expert manipulation for their application (i.e. Ebon and Gaschell). Others, which consist of a solution of the lining material in an inflammable and low boiling solvent, are applied by a brushing or rolling process directly on to the wood, which, however, must be well dried before



FIG. 23.

Baumann "bell" flash pasteurizer (showing inner and outer surfaces).

treatment. In the case of one material (Dukeron) the casks are de-headed, and dried by means of a small brazier previous to the application of the lining. Such linings enable one of the chief disadvantages of cask storage, i.e. the lack of airtightness, to be overcome, but unless exceptionally sound casks are chosen, the irregularities of the wooden staves are likely to render their complete hermetical sealing a very difficult matter.

It appears to be certain that storage of sterile, culinary, apple juices in ordinary wooden casks, even if of sound construction, is by no means safe, even when very stringent precautions are carried out.

### (c) Storage in glass jars

In view of the comparatively straightforward methods available for sterilizing 5-10 gallon glass jars, a certain small quantity of apple juice is stored in these vessels in Germany. 2%  $\text{SO}_2$  solution is used for sterilization or alternatively steam is injected until the glass becomes quite hot. A simple fitment, similar to that used at Long Ashton for filling casks is used for filling the jars. In general, however, glass jars are used only for the reception of hot processed juice.

### (d) Storage in bottle (Immediate bottling)

The fourth method of storage by the cold process is to receive the juice from the outlet of the sterilizing filter straight into sterile bottles which are closed with sterile corks. This procedure raises the whole question of sterile bottling, and this process will be discussed in a later section (18 B).

If this method be adopted, it is very desirable to ensure that the juice will not throw a deposit later in its storage life. Cold sterilization by filtration does not inactivate the enzymes, either those occurring naturally or those added to expedite pectin removal, and unless all the changes in composition are completed before filtration the enzymes will continue their functions after filtration and bottling. In these circumstances it is advisable to follow the course of pectin removal and to allow its completion before proceeding with the clarification of the juice.

## B. Hot process

### (a) Storage in glass jars

The rapid expansion of the hot process in Germany, largely due to its ready adaptability by small producers, has been accelerated by the development of the "flash" type of pasteurizer and the Baumann cap, which latter fitment solves the difficulty of obtaining an effective seal on the jar.

The German bell type of pasteurizer (Fig. 23) is very effective and constitutes a most convenient and economical means of stabilizing apple juice. The method has one great advantage over the cold process, in that when the hot juice is filled into the storage containers (which are usually glass vessels of the demijohn type holding 5-6 gallons) the inner surfaces of the glass jar are automatically sterilized by the hot juice. The fitting of a rubber cap completely seals the vessel and retains the necessary sterility in the product (Fig. 24).

Temperatures need close attention. It is usual to employ a pasteurization temperature of  $180^{\circ}$ - $195^{\circ}$  F. for 10-20 seconds only, and to cool the juice down immediately to such a temperature as is necessary merely to sterilize the inner surface of the glass container. This temperature may be  $155^{\circ}$ - $170^{\circ}$  F.

The cost of the special aluminium pasteurizers with an output of 25-100 gallons per hour is only about £5-£25. The use of this metal, however, cannot be recommended, as much corrosion occurs, but new alloys, as used in Zeppelin construction, are now used in Germany and offer much greater resistance to the corrosive action of fruit juices. Stainless steel equipment of similar capacity is obtainable at prices about four times that of the corresponding aluminium alloy pasteurizers. It will be seen that for any producer who already possesses a mill and press the new equipment needed is very reasonable, and this accounts for the fact that so many smaller producers on the Continent are using the hot method.

English pasteurizers of the heat exchanger type are available for the flash treatment of apple juice. Stainless steel surfaces are used wherever the juice comes into contact with the

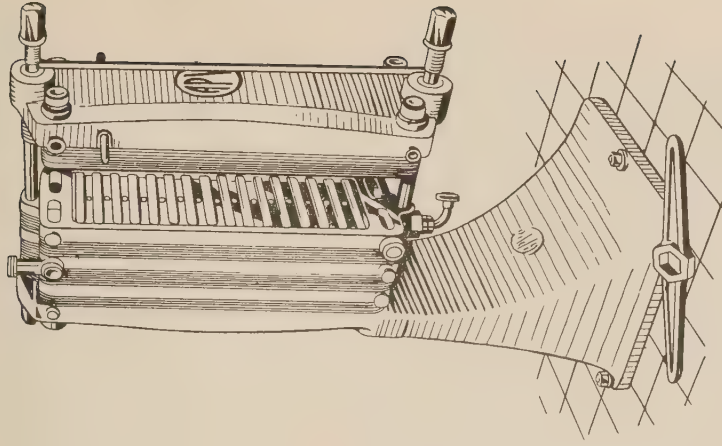


FIG. 25.  
Flash pasteurizer for fruit juices  
(Aluminium Plant & Vessel Co.).



FIG. 24.  
Glass jar and Baumann rubber caps for hot process storage.

metal. A special form of this type of machine made by the Aluminium Plant and Vessel Co. (London) (Fig. 25) has been tried in commercial factories and at Long Ashton Research Station with every success. The heat exchanging system is so efficient that the supply of cooling water is reduced to an absolute minimum. One important point, however, has been noted in the manipulation of this plant. A smooth and steady flow of juice through the plates is essential and air locks, arising from the evolution of gas from the juice as it enters the heating spaces, are potent causes of interrupted flow. Avoidance of air locks has been found to be possible only by subjecting the juice to a thorough deaeration prior to its passage through the pasteurizer. This point should be given due attention while the length of time allowed for the enzyme treatment is being decided, for some fermentation is invariably found to have occurred before there are any visible signs of its progress.

The effect of pasteurization on flavour is discussed later.

### (b) Bulk storage

The storage of hot processed apple juice in large bulk is practised in Germany in several factories where the pasteurization method is adopted. The vessels usually favoured are steel tanks with some form of lining similar to those described previously in connection with the Boehi pressure tanks. The strength of the tanks, however, needs to be sufficient only for actual retention of the juice and in consequence their construction is of a lighter type than that needed for the cold process vessels.

The tanks are previously sterilized by  $\text{SO}_2$  or steam, and the juice is filled in directly from the pasteurizer, usually at a temperature of  $68^{\circ}\text{--}72^{\circ}\text{C}$ . ( $154^{\circ}\text{--}162^{\circ}\text{F}$ .). The normal size of tank holds 2,000 gallons and is filled in 3 hours. A sterilizing filter is attached to a fitment on the top of each tank and protects the juice from air infection. The hot juice is cooled by spraying the outside of the tanks with cold water—the process usually needing 2-3 hours for its completion.

### (c) Storage in bottle

This is probably the oldest method for storing apple juice. The clarified juice (i.e. pulp filtered) is filled straight into bottles which are corked and, if necessary, wired, and pasteurized at  $150^{\circ}\text{--}165^{\circ}\text{F}$ . for 30 minutes. Whilst this process can be applied equally well to gallon jars made of suitable glass, it is not used for larger vessels, although it is possible to flash pasteurize apple juice at  $185^{\circ}\text{F}$ ., and cool to  $160^{\circ}\text{F}$ . and receive the juice into warm glass bottles.

There is not the same probability of the occurrence of pectic and other deposits in juice pasteurized in bottles as in the cold processed beverages. The enzymes which effect a slow decomposition of the complex series of organic constituents in the juice are inactivated simultaneously with the yeasts and bacteria. In some cases, however, purely chemical factors may result in the formation of a flocculent deposit of pectic substances.

## C. Dispensers for apple juice in bulk

Apple juice can be supplied in bulk to hospitals, clinics, hotels, railway station buffets and schools in vessels of various sizes and made of different types of materials. Fig. 26 shows two sorts which are in use in Germany. The plain vessels are made of an aluminium alloy which, however, has shown signs in use at Long Ashton of being affected to some extent by the juices. The Most-Max tank is porcelain-lined and whilst no effect of the lining on the flavour of the juice has so far been discovered the lining is fragile and is easily fractured. Fig. 27 shows the latest form of stainless steel dispensing vessel made in England. The 5 or 10 gallon drum is fitted with a patent Barnes combination plug to ensure absolute sterility of the contents even when the dispensing "spear" is forced down into the juice. Stainless steel has proved to be a suitable metal for long term contact with apple juice.



FIG. 26.

German aluminium and porcelain-lined vessels for dispensing fruit juices.

## 18. Bottling

It is clear from what has been described in the previous section that the bottling technique to be employed will depend on whether cold or hot processes are desired. There are, however, certain points common to both processes which may be considered first.

### A. General considerations

#### (a) Type of bottle

Many forms of bottles, excepting those with screw stopper closures, have been satisfactorily used for the reception of apple juice. In Germany, considerable use is made of the

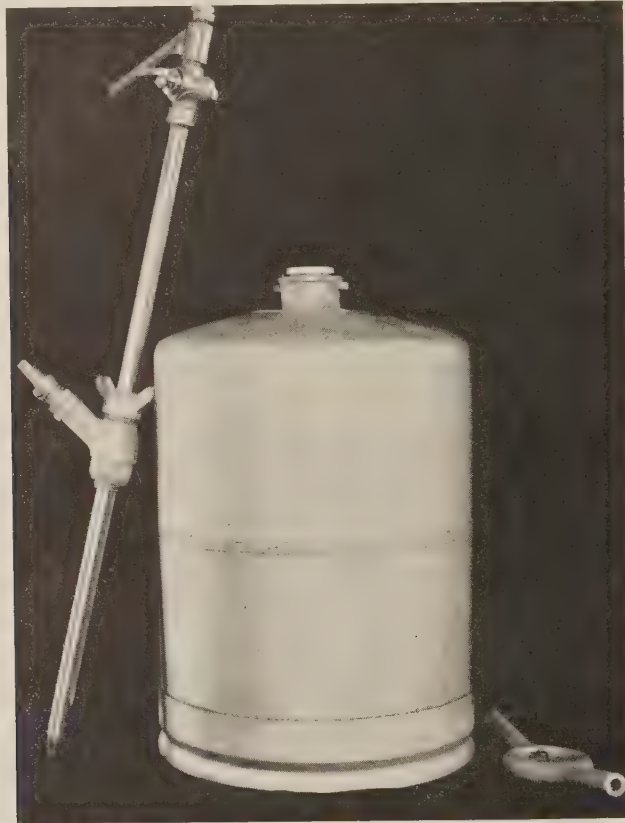


FIG. 27.

English stainless steel vessel with dispensing spear.

type and shape of bottle associated with Hock and Moselle wines (750 c.c. or 1 l. capacity). These containers are closed either by corks or crown closures. Certain other forms of bottles have been introduced, chiefly in the smaller sizes (i.e. 200-350 c.c.). The main consideration in choosing bottles for unfermented juices is that they should be of such a strength and shape that they can be efficiently washed and brushed prior to their final sterilization. The glass should be capable of withstanding suddenly applied temperatures up to 120° F., whilst the shape should be such that the normal bottle washing and brushing equipment is able to contact the whole interior area of the bottle.

### (b) Bottle washing

The cleansing of bottles varies in matters of procedure and method from plant to plant, and different recommended treatments are associated with almost every type of commercial machine. However, the general procedure is composed of 4 consecutive manipulations :—

- (i) Soaking in water or very weak detergent solution for softening and removal of labels. (This may be omitted if labels are easily removed.)
- (ii) Soaking in hot detergent (20 minutes at 140-160° F.). Draining of bottles.
- (iii) Interior and exterior brushing of bottles.
- (iv) Rinsing with clean water.

Bottles treated in this way will not generally be bacteriologically sterile. For the cold process further sterilization with 2 per cent.  $\text{SO}_2$  or steam is necessary, but the bottles in the condition in which they leave the rinser can be used for filling by the hot process.

### (c) Detergents

Caustic soda is the basis of the majority of the commercial detergents. There is a gradually increasing use of metasilicates in combination with soda, but whatever may be the composition of such detergents, it is necessary to maintain a free causticity of at least 1 per cent. in the washing solution. This involves the regular standardization of the solution and the addition day by day of further quantities of detergents to ensure effective sterilization.

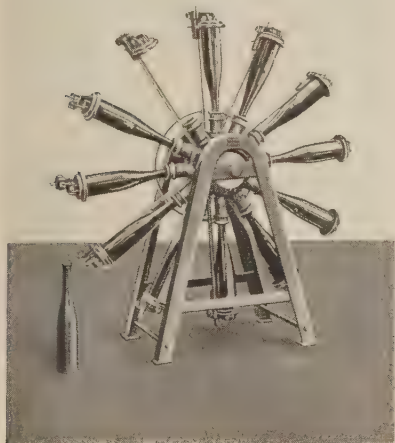


FIG. 28.  
"Stella" wheel for sterilizing bottles  
with  $\text{SO}_2$  (Seitz).



FIG. 29.  
Formalin sterilizer for crown corks  
(Seitz).

### (d) Steam sterilization

This process is used in Germany and Holland subsequent to the above form of soaking and brushing treatment. The bottles are conveyed on moving belts through a steam chamber and are subjected to a temperature of 100° C. for 20 minutes. This process is capable of providing bacteriologically sterile bottles.

### B. Cold process bottling

The juice for this process will almost invariably be stored in Boehi tanks—thus providing a completely cold process throughout. But whereas the juice in properly equipped pressure tanks can be retained in a completely stabilized form merely by the maintenance of the  $\text{CO}_2$ ,

pressure at the necessary level, there is no such straightforward and simple means of ensuring sterility in the filling process and in the bottled product. It may appear to those who have not been concerned with this form of treatment that the difficulties of cold stabilization are being unduly laboured, but it is only when the significance of the various problems are correctly and fully appreciated that the necessary steps can be taken to obviate the troubles that arise from unsterile conditions.

There are three separate problems to be dealt with, namely, the sterility of the plant (including bottles), bottling room, and, finally, scrupulous cleanliness of personnel.

#### (a) Sterilization of plant (78)

Steam or 2%  $\text{SO}_2$  are used for this purpose and formalin (1% strength) is a useful disinfectant where  $\text{SO}_2$  cannot be used. From the outlet of the sterilizing filter, the sequence of

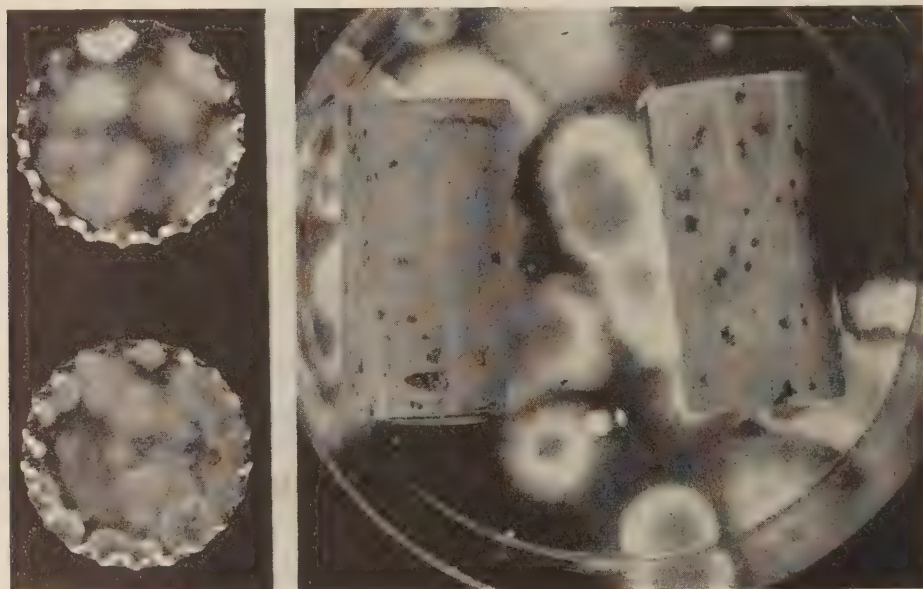


FIG. 30.

Effect of incomplete sterilization on bottle closures.

plant to the bottling and corking machines must be rigorously sterilized, and the bottles themselves must be treated on some form of wheel which permits of a soaking and rinsing with 2%  $\text{SO}_2$  (Fig. 28). The corks, too, must be treated in some similar manner. The usual procedure is to leave the corks in 2%  $\text{SO}_2$  for 12 hours before use, the corks being taken out of the receptacle by means of a rubber glove. Wooden tubs with closely fitting lids enable the corks to be submerged beneath the sterilizing solution. It is not safe to rely on the sterility of corks treated for only a few minutes in 2%  $\text{SO}_2$ ; there is need for penetration of the disinfectant into the pores of the cork, and a considerable time factor is involved here. Crown corks cannot be treated in  $\text{SO}_2$ , in which case formalin or steam must be used. Crown cork sterilization in Germany is carried out by a special form of apparatus in which formalin is allowed to act, under the influence of a gentle heat, upon the crown closures which are contained in a porous bag placed within a closed metal vessel. The apparatus is illustrated in Fig. 29.

Neglect to take this precaution is likely to lead to results similar to those depicted in Fig. 30 in which unsterile corks and crown corks are shown.

The  $\text{SO}_2$  should be removed from the various vessels or machines by the agency of sterile water. This is necessary as the presence of  $\text{SO}_2$  in more than very minute doses is apparent on the palate.

(b) Sterilization of bottling room (78)

The bottling room is the most important section of the whole factory. In it is centred the single process of bottling, but complete success or failure with the product is determined by the efficiency of the processing for which this room has to be designed. The room should be capable of being completely sterilized from ceiling to floor. White glazed tiles are the best choice for the inner walls, but any clean, smooth surface that will not crack and can be washed and sprayed with some form of disinfectant is also suitable. Tiles have a definite advantage over other surfaces from the point of view of steam sterilization. German technicians favour the filling of the room with steam for 1 hour, and painted wooden walls are not satisfactory over long periods when subjected at frequent intervals to this intensive steaming. The site should be chosen with care and the outer windows (if any) should not overlook any known regular source of yeast or other microbiological infection. The room should be completely separated from any adjoining rooms, except that generally a turntable is fixed into the wall leading to the bottle washing room. Hence, only clean bottles that have been sterilized with  $\text{SO}_2$  enter the bottling room. There is also the bottle rinser to remove  $\text{SO}_2$  (Fig. 31), the sterilizing filter (Fig. 32), the corker (Fig. 33) and an outlet for the filled bottles, either similar to the turntable for their entry, or consisting of a narrow conveyor passing out through a slit in the wall. No other plant should be allowed in the bottling room and the most scrupulous cleanliness should be observed with regard to everything which has been outlined above.

Special reference should be made to the bottle rinser. The Seitz Satrap machine enables a jet of sterile water to be forced into the bottles which enter the sterile room by means of the turntable device. As the bottles are usually inverted and placed in the turntable with their necks immersed in an  $\text{SO}_2$  solution, it is necessary to effect an almost complete removal of the  $\text{SO}_2$  previous to filling the juice into the bottle. The rinser consists of a small Seitz E.K. filter and a device for forcing a jet of sterile water into the bottle to which is connected the high power water supply. The rinser and sterilizing filter should be sterilized outside the sterile room, but the circulation of cold water can be carried out in the bottling room. All outlets in the filter must be protected by swabs of cotton wool soaked in 2%  $\text{SO}_2$  solution until the plant is installed in the bottling room and the necessary connections have been made. The surfaces of the rinser, filter and corking machine are often given a final sterilization by directing a blow lamp flame over all the exposed surfaces.

There can be no doubt that the above arrangements and precautions are necessary. Very few detailed examinations of the cold process have been reported outside Germany, but Charley (30) has published data which show that whilst the sterilizing filter (in this case, the Seitz E.K.) gave completely sterile juices, it was practically impossible to fill these juices into bottles in the open in an ordinary cider factory without the incidence of much fermentation later. The most minute attention to detail in the sterilization of bottles and corks was found to be absolutely essential. The normal washing of bottles with detergents which afford satisfactory results for cider purposes was shown to be quite useless for apple juice work, and the experience gained in four years' experimental work indicated that the cold process of bottling

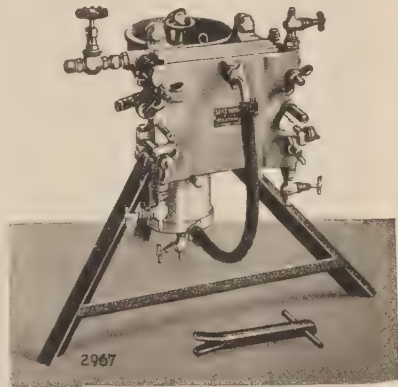


FIG. 31.  
"Satrap" bottle rinser to remove  $\text{SO}_2$   
(Seitz).

apple juice necessitates the expert knowledge of a scientifically trained technician who will apply meticulously to every detail of the process all the available knowledge on the subject.

(c) Sterility of clothes of workmen (78)

The appreciation by the food industry of the importance of preventing infection of the product or the plant by the clothes of the workmen has led to the large scale provision of white linen suits and hats for those of the personnel who come into contact with food products. From the point of view of apple juice, the sterility of the bottling room may be severely prejudiced by the unsterile clothes of one of the men and it is recommended that special suits and hats be

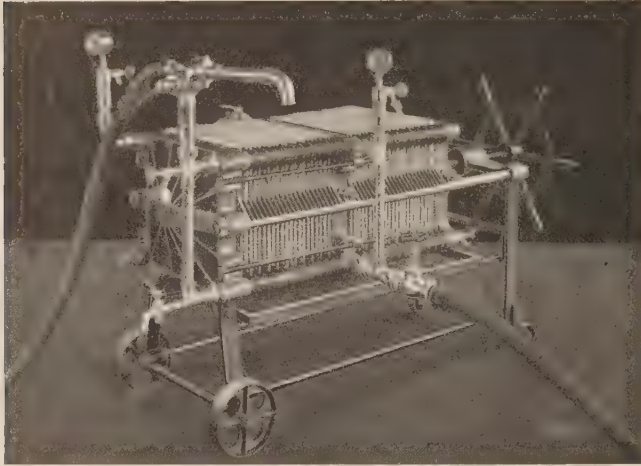


FIG. 32.

Seitz filter (suitable for use with clarifying (K) or sterilizing (EK) discs).

made available to those actually working in the room. These clothes should be reserved for use in the bottling room and when not in use stored in closed lockers. Apart from the actual gain in sterility, the white clothes create a psychological atmosphere which tends towards greater efficiency and more intelligent workmanship in the factory. The workmen in the bottling room should be chosen for their capability of performing the various functions with the care and efficiency demanded by the process. They will normally be higher grade employees than those associated with the other phases of the factory routine.

(d) Automatic bottling

Recent years have seen the introduction of the automatic bottling machine which avoids some of the difficulties which have already been mentioned (such as infection from the surroundings) but thorough sterilization and

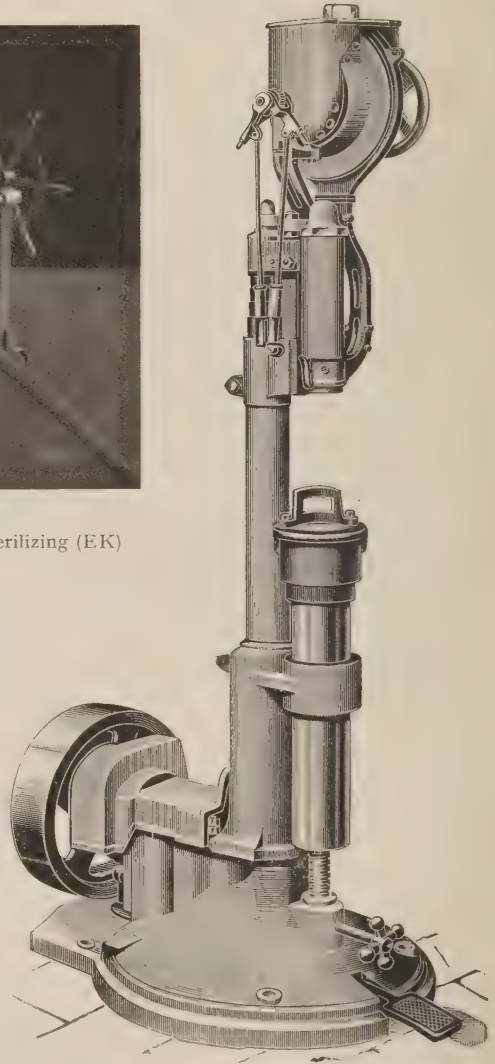


FIG. 33.

Power crown corking machine (Clayton type).

the greatest care in operation are still required. The machines are of some complexity but on the Continent it appears that they have proved to be satisfactory in cases where the fundamental problems involved in their operation are fully appreciated.

The following exact procedure in the case of a large up-to-date German automatic bottling plant indicates the attention that is paid to detail in this process.

The washed and rinsed bottles are steam sterilized in a machine which is built into the sterile room in such a way that whilst the bottles are fed into the machine from the outside, the sterile bottles are delivered directly on to a moving belt inside the sterile room. The bottles immediately enter a protective glass chamber, within which they are filled. The crown corking

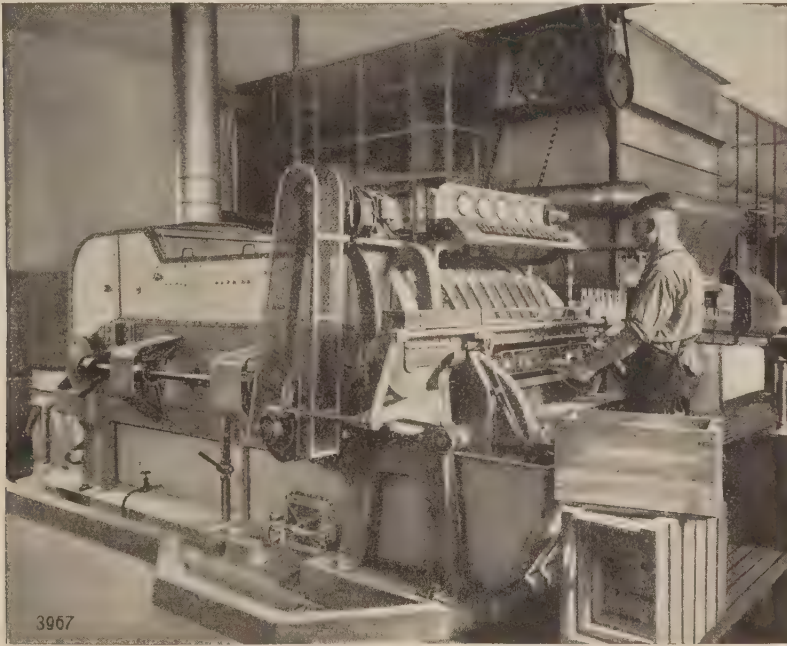


FIG. 34.  
German sterile bottling room. A. Bottle washing.

machine is adjacent. The caps are sterilized by a gas flame immediately prior to being pressed on the bottles. The containers move forward on a narrow belt and pass out of the bottling room through a narrow aperture. Complete sterility of the plant and room is effected by an intense steaming, whilst the possibility of an influx of germ-laden air is prevented by the maintenance of an excess pressure of one atmosphere within the room. As a direct result of this pressure, there is a continual flow of air passing out through the aperture outlet for the filled bottles. The air used to maintain the enhanced pressure is sterilized by a Seitz air filter. The actual plant is illustrated in Figs. 34-38.

The general lay-out of the preparation, storage and bottling of apple juice by the Seitz cold process is shown in two diagrammatic illustrations (Figs. 39 and 40).

### C. *Hot process bottling*

There remains but little to add to what has been said in Section 17 B concerning the hot process of bottling apple juice. The process differs from that already described only in

respect of the final container. In some cases the bottles receive the juice from the flash pasteurizer at such a temperature that their inside surfaces are sterilized by the hot juice. The drawback of this method is that it involves the maintenance of a fairly high temperature in the juice for a longer period than is desirable, whereas the aim should be to reduce the temperature as much as possible immediately after it is delivered from the pasteurizer.

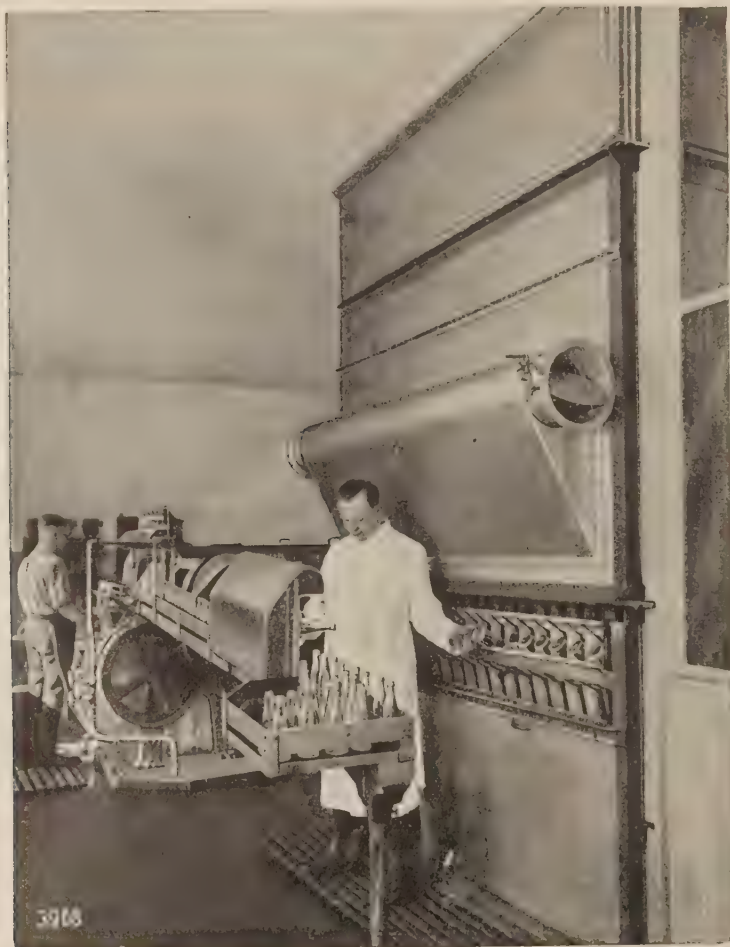


FIG. 35.  
German sterile bottling room. B. Entrance to steam sterilizer.

In view of the desirability of immediately reducing the temperature of the pasteurized juices to as low a figure as is commensurate with satisfactory sterility in the filling procedure, the Long Ashton workers\* have recently examined the effect of various pasteurization temperatures in association with much lower filling temperatures than have hitherto been considered possible. The juices were received into bottles which had been treated in various ways to affect their sterility. All the bottles were given a normal detergent soak for 20 minutes at 160° F.,

\* In course of publication in *Annual Report Long Ashton Research Station, 1938.*

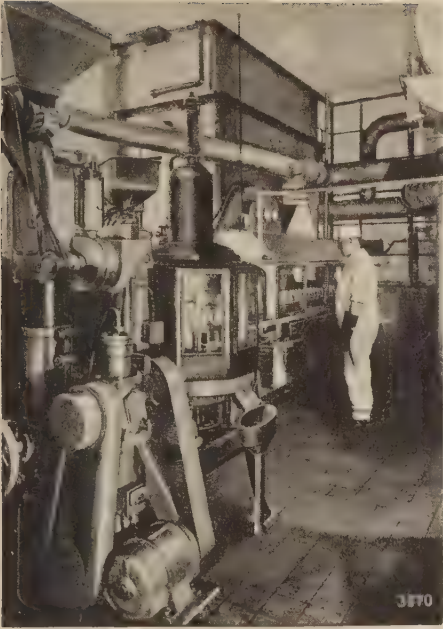


FIG. 36.  
German sterile bottling room. C. Interior  
view showing bottles moving from outlet  
of steam sterilizer to filling machine.

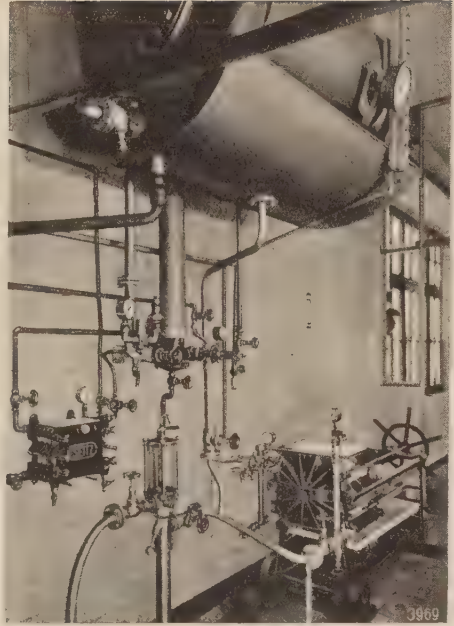


FIG. 37.  
German sterile bottling room. D. Control  
equipment: Seitz air and juice filters, etc.

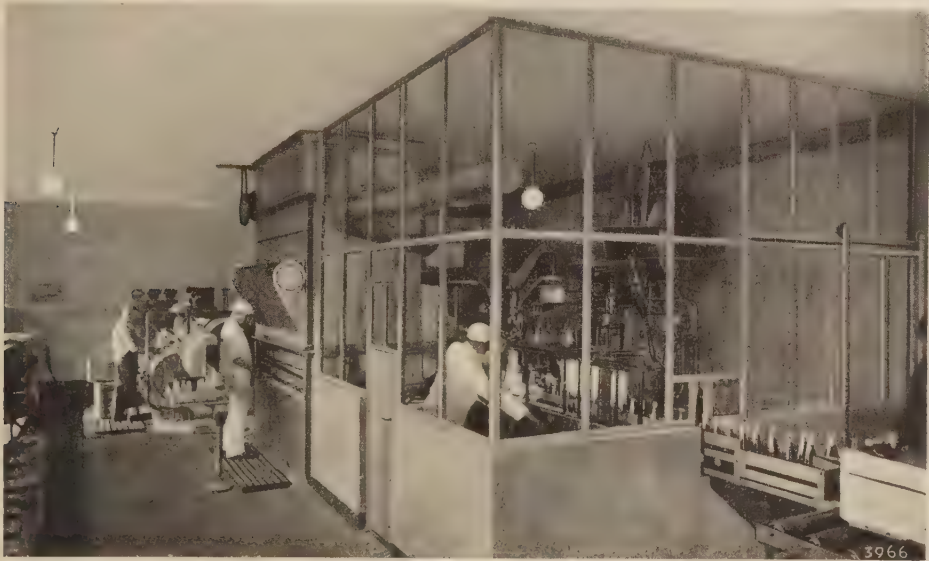


FIG. 38.  
German sterile bottling room. E. General view.

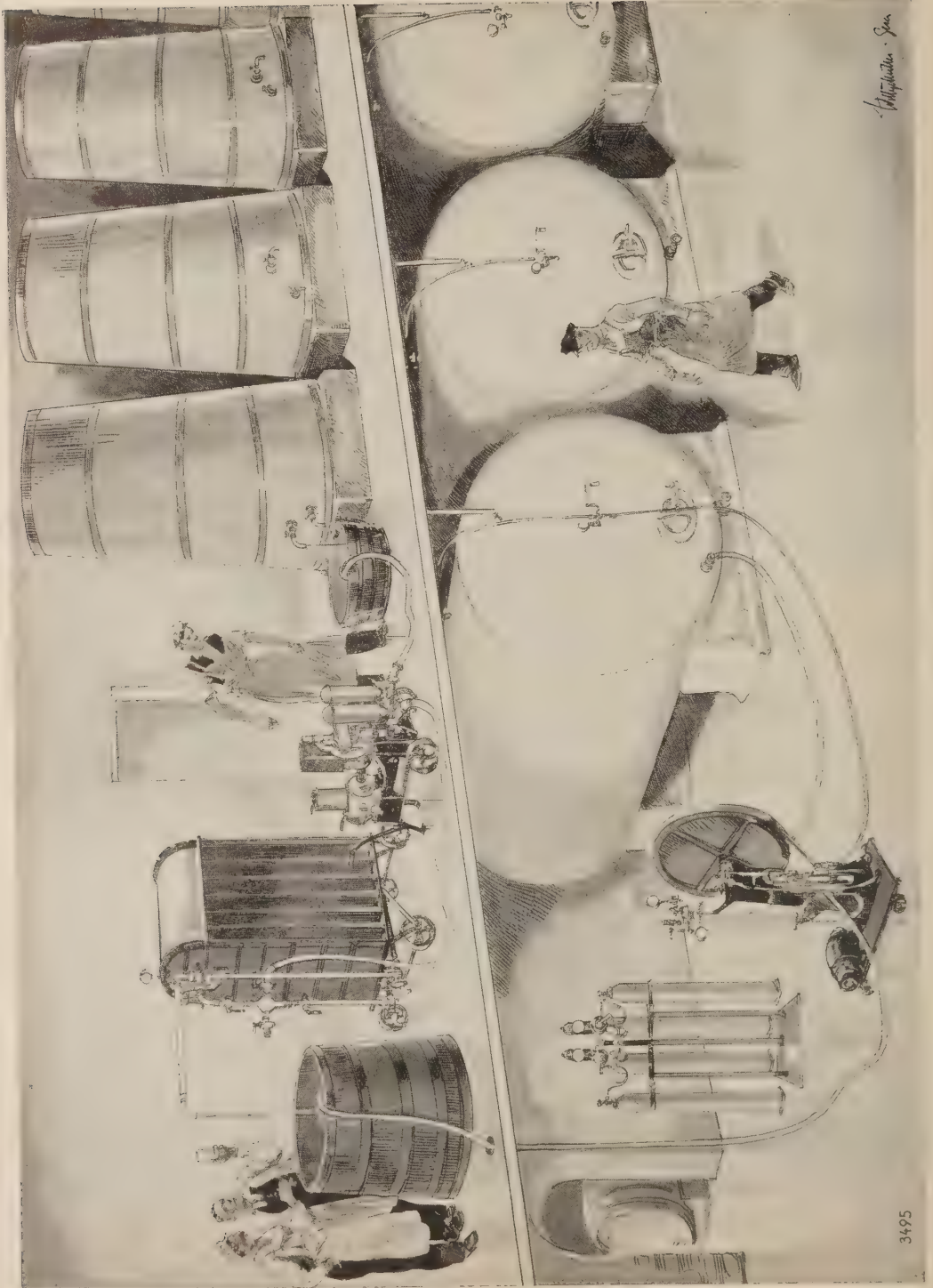


FIG. 39. Diagrammatic view of cold processing of apple juice.



FIG. 40. Diagrammatic view of cold process bottling of apple juice.

followed by brushing and rinsing. The subsequent treatments, together with the resultant sterilities of the bottles previous to filling are given below :

- A. Bottles filled cold (variable but considerable numbers of yeasts).
- B. Bottles heated in a steam chest for 20 minutes and filled when at a temperature of 150° F. (practically free from yeasts).
- C. Bottles passed over sulphuring wheel containing 2% SO<sub>2</sub> and filled after draining for one minute (slightly more sterile than B. or D.).
- D. Bottles passed over sulphuring wheel as for C. and filled after being rinsed by Satrap machine (sterility same as for B.).

The salient features of these preliminary tests are given in Table 6.

TABLE 6  
EFFECT OF VARIOUS PASTEURIZING AND FILLING TEMPERATURES ON THE STABILITY OF APPLE JUICES STORED IN BOTTLES OF VARYING STERILITY

| Flash pasteurizing temperature. | Filling temperature. | Treatment of bottles. | Results of 1 month's incubation test on bottled juices at 25° C. |
|---------------------------------|----------------------|-----------------------|------------------------------------------------------------------|
| 185° F.                         | 160° F.              | A                     | Fermented.                                                       |
| "                               | "                    | B                     | Free from yeast growth.                                          |
| "                               | "                    | C                     | " "                                                              |
| "                               | "                    | D                     | " "                                                              |
| 185° F.                         | 140° F.              | A                     | Fermented.                                                       |
| "                               | "                    | B                     | Free from yeast growth.                                          |
| "                               | "                    | C                     | " "                                                              |
| "                               | "                    | D                     | Fermented.                                                       |
| 185° F.                         | 90° F.               | A                     | Fermented.                                                       |
| "                               | "                    | B                     | " "                                                              |
| "                               | "                    | C                     | Free from yeast growth.                                          |
| "                               | "                    | D                     | Fermented.                                                       |
| 160° F.                         | 160° F.              | A                     | Fermented.                                                       |
| "                               | "                    | B                     | Free from yeast growth.                                          |
| "                               | "                    | C                     | " "                                                              |
| "                               | "                    | D                     | " "                                                              |
| 155° F.                         | 140° F.              | A                     | Fermented.                                                       |
| "                               | "                    | B                     | Free from yeast growth.                                          |
| "                               | "                    | C                     | " "                                                              |
| "                               | "                    | D                     | Fermented.                                                       |

It is also possible to cool the flash pasteurized juice to 155° F. and fill it into bottles that have been pasteurized by heat or SO<sub>2</sub> and which are taken from a tank of water, which is maintained at 155° F. Alternatively the bottles may be heated by steam jets or by sprays of hot water immediately prior to being filled with hot juice. Cooling in the air will ensure the retention in the juice of sufficient heat to effect the sterilization of the bottles. German procedure is influenced by the need for absolute freedom from fermentation and the bottles are generally stored in cases and kept hot for such a considerable period that the juices are virtually subjected to a "holding" pasteurization in addition to the short high temperature treatment.

A simple bottling machine is shown in Fig. 41, the latest type of British continuous bottling and capping machine in Fig. 42, and a combined carbonator and bottler in Fig. 43.

The final pasteurization may also take place in the bottles themselves. Automatic plants are available for this purpose, but very simple arrangements can be devised for the efficient treatment of the bottled product. Any form of vessel large enough to hold sufficient water for the immersion of bottles can be used. Heat can be maintained by steam pipes, by gas or electricity, and can be regulated by hand or controlled automatically. Fairly even distribution of temperature is desirable. The bottles should be immersed in water at a temperature of about 100° F. (this has been found safe for all the usual type of bottles) and the

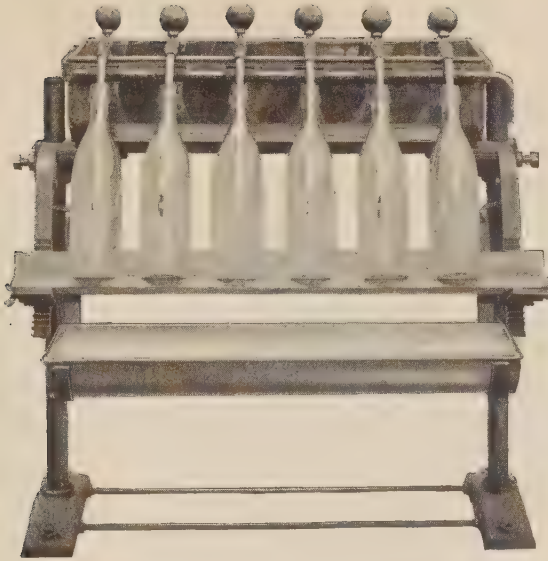


FIG. 41.  
Stainless steel syphon pipe filler.

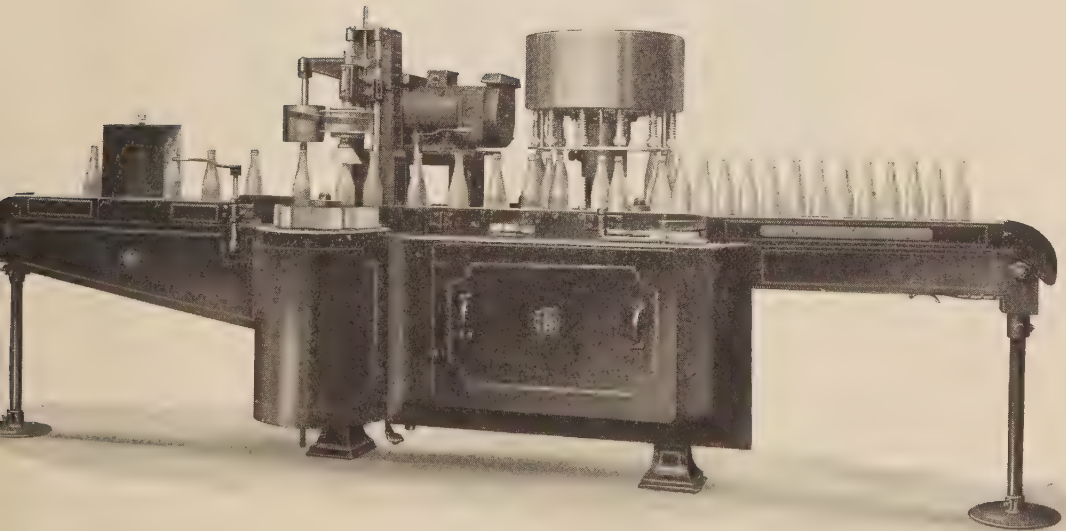


FIG. 42.  
Stainless steel continuous bottling and capping machine.

temperature of the water raised until the juice in the bottles reaches 150°-160° F. The temperature should be maintained at this level for 15-30 minutes, depending on the length of time taken to raise the temperature of the bottles from 100°-150° F. In all pasteurization work it is desirable to have thermometers in one or two of the bottles of juice themselves and not to pay undue attention to the temperature of the heating water. With juice made from culinary fruit, it is advisable to pasteurize at 150°-160° F. for half an hour.

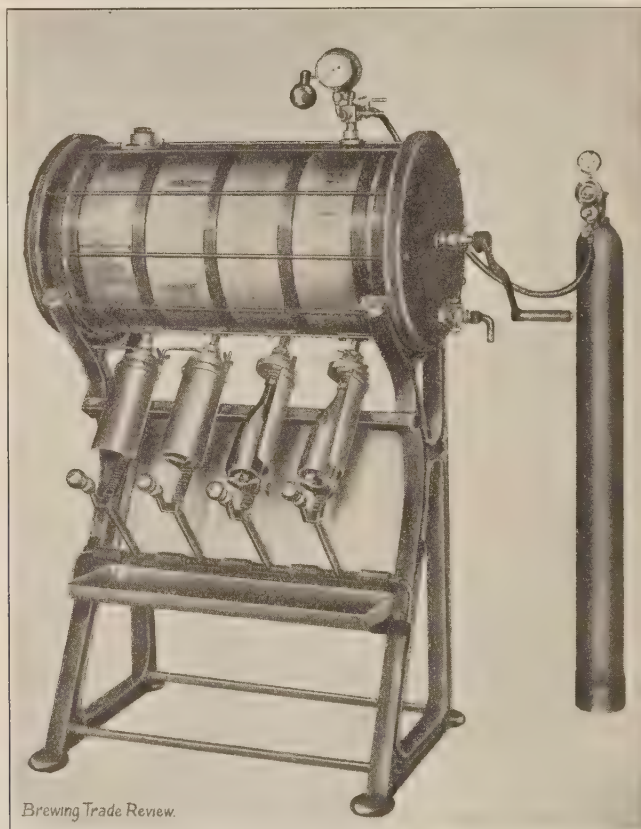


FIG. 43.  
Combined carbonating and bottling machine.

## 19. Canning

The canning of apple juice has been examined by workers in America, Canada and England. Various procedures have been suggested and are briefly described below.

Joslyn and Marsh (59) and Marsh (65) state that the usual procedure for canning apple juice includes flash pasteurization at 190° F., cooling the juice to 175° F. and filling at this temperature straight into plain or lacquered cans which are then sealed, inverted and allowed to cool.

Celmer and Cruess (41) have produced canned, carbonated apple juice. The filtered, deaerated juice was carbonated at 30 lbs. per square inch and filled into crown cap, beer type cans, with interior lacquer covered with wax. The sealed cans were pasteurized at 140° F. for

30 minutes, and then quickly cooled. Three months' storage at 85° F. did not affect the can, and there was no cooked or extraneous taste noticeable on the palate.

The wax lining of the can apparently absorbed and removed from the juice a slight press-cloth flavour which was apparent both in the fresh juice and in the bottled juice, to that extent improving the flavour of the product.

Joslyn and Marsh (59), referring to the stabilization of juices in the can, give the following details: the cans are filled with cold juice, closed under vacuum and processed in an agitating water bath for the required time. Specific details are not given for apple juice, but for orange and grapefruit products in No. 1 cans the juices are pasteurized at 165° F. for ten minutes, tomato juice at 212° F. for 20 minutes, and other juices (presumably including apple) at 175° F. for 20 minutes.

Arengo-Jones in Canada (1) has found it possible to pack a juice in tin cans coated with mineral oil. The oil is applied hot to the heated cans, and the excess removed by inverting the can over a steam jet for 10 seconds. The apple juice is filled into cans at 175° F. and sealed immediately, the cans being allowed to stand for a few minutes before being cooled.

The canning of English apple juice has been studied at Long Ashton by Charley in the years 1934-8 (30). The investigations arose from the desire to determine whether cans could be used for long term storage, thus avoiding the use of large tanks or the inconveniently large number of glass vessels that are needed when large stocks of juice are stored by this means. The experiments were arranged to cover the whole question of the preparation of the apple juice, and the results can conveniently be considered at this stage.

The scheme for the complete processing that is considered to afford the best results is as follows: mill and press the fruit; macerate with disintegrated presscake for 12 hours; deaerate at 29" vacuum; flash pasteurize (where fermentation is likely) at 190° F. for 20 seconds; remove macerate; cool; add enzyme to juice; allow enzyme to continue its action for 2-4 days, following course of removal of pectin by some convenient method; centrifuge to remove deposit; adjust gravity and acidity if correct composition is unobtainable by blending; filter to a brilliant condition; deaerate and pasteurize as before; cool to 142° F.; can at this temperature straight into waxed, lacquered cans; invert cans; allow to cool naturally.

The experimental work was carried out on a semi-commercial scale and many thousands of cans were processed. The limitation regarding the temperature beyond which the juice must not be filled into the cans (142° F.) is imposed by the fact that the wax lining melts at 145° F. Despite this somewhat low temperature of filling and the absence of any previous sterilization treatment for the can, perfect stability was found with unfermented juice from Bramley's Seedling apples and with mixed batches of surplus dessert and culinary varieties. The process also affords a stable juice from the point of view of clarity, for the stabilized juices remained bright over a very considerable period.

Plain cans were shown to be absolutely useless, even when deaerated juices were filled into them. Ordinary lacquered cans were uncertain in their behaviour, but a number were examined and found to have become pitted. Other linings such as berry enamel in U.S.A. and specially deposited materials as developed in England have shown promise of being sufficiently resistant to juices to obviate the need for a wax lining.

The experiments have indicated the possible value of the can as a convenient means of storage of apple juice. Sterilization of the container is achieved by the hot juice, and the process of filling is not accompanied by many of the risks associated with the filling of pasteurized juices into bottles or with the cold process. In general, the can is cheaper than a similar sized bottle and although it is used only once, the expenses relating to collection and washing of returned bottles are completely avoided. Low freight charges and the absence of breakages constitute two further advantages of cans over bottles as apple juice containers.

A machine suitable for filling cans is shown in Fig. 44.

## 20. Bottle closures and their sterilization

The safe keeping of apple juices in bottles or cans can be seriously prejudiced by failing to take the necessary precautions for sterilizing the closures for the containers. The various types of closures fall in the three following groups.

### A. Corks

Owing to the difficulties both of efficient sterilization and of withdrawing the cork in the absence of a suitable appliance, corks are not now generally favoured as bottle closures for apple juice. Treatment with 2%  $\text{SO}_2$  for 12 hours is needed, and precautions are necessary with certain grades of corks to prevent the cloudy drop of liquid exuded from the cork when being compressed from falling into the juice in the container. Corking machines in Germany can be arranged so that the cloudy drop of liquid is either sucked or blown off the end of the cork. Good quality corks are not generally prone to this disadvantage and consequently should always be chosen for this type of work. Bottles closed with corks should never be stored in a vertical position on account of the liability of the cork to dry out and to permit of the growth of micro-organisms down the side of the cork and thence into the juice.

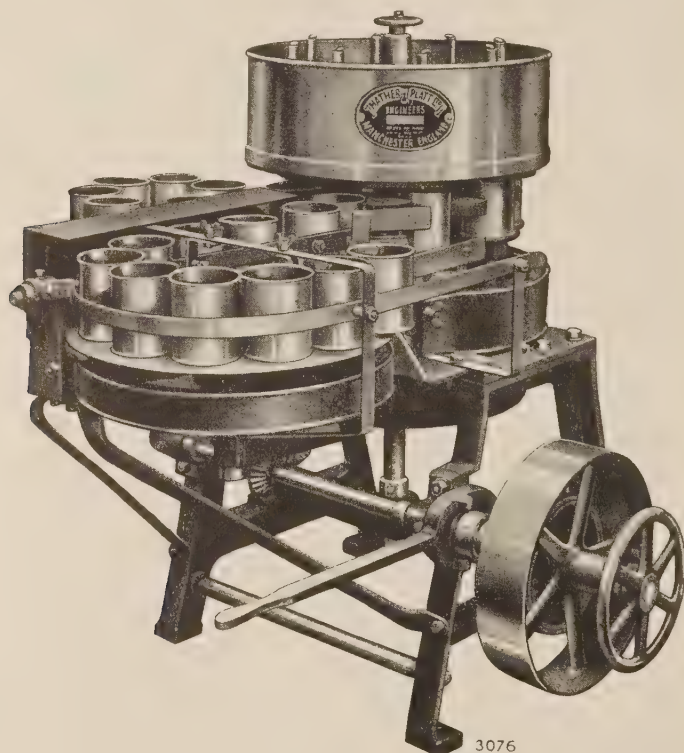


FIG. 44.  
Can filling machine.

### B. Crown corks

Where bottles with crown cork necks are available this type of closure is simple and effective. Considerable importance attaches to the prevention of contact of the juice with the cork or the metal of the cap. For this purpose circular discs of various materials are imposed on the cork lining of the closure. Such materials include aluminium-coated cellophane, cellulose-oil centres, and rubber discs. The usual form of crown cork is not suitable for  $\text{SO}_2$  sterilization, either steam or formalin being used for this purpose.

### C. Composition seals

A new type of seal which can be removed simply by pulling an exposed flap and tearing off the entire closure has many advantages. A rubber lining is fitted inside the seal and a perfect

closure is ensured. This type of seal is of special use where pasteurization is carried out on the filled and sealed bottles or cans.

## 21. Outline of possible sequences for processing

In view of the alternative methods of treating apple juice by the hot and cold processes, and the several ways available of effecting clarification and sterilization, the following outline is included to indicate the general sequence of the various processes as usually adopted by the apple juice industry. The processes placed within brackets are of newer introduction and are not yet in general use.

### *Hot process*

Mill and press the fruit.

(Macerate juice with press cake.)

(Remove macerate.)

(Deaerate and flash pasteurize juice.)

Treat with pectin-decomposing enzyme.

Clarify juice by centrifuge, pulp or kieselguhr filter.

(Deaerate juice.)

Flash pasteurize juice into tanks, glass jars or bottles, or

Fill juice into bottles and subject to holding pasteurization.

After storage in tanks or jars :—

Pulp filter juice to brilliant condition.

(Deaerate.)

Flash pasteurize into bottles or cans, or

Fill bottles or cans with cold juice and subject to holding pasteurization.

### *Cold process*

Mill and press the fruit.

(Macerate juice with press cake.)

(Remove macerate.)

Treat with pectin-decomposing enzyme.

Centrifuge or filter through kieselguhr or coarse filter pads.

Impregnate with CO<sub>2</sub>.

Store in pressure tanks.

After storage :—

Remove CO<sub>2</sub>.

Filter through pulp filter or coarse filter pads.

Sterilize by filtration.

Bottle in a sterile manner.

In several factories it is the practice to combine certain features of the two processes, storing the juice in bulk in pressure tanks and finally stabilizing the juice when being prepared for consumption by flash pasteurization into bottle. By this means, the juice receives only one heat treatment and the flavour is correspondingly less subject to change.

## 22. Other methods of stabilization

During recent years three other processes for stabilizing apple juice have been introduced and have made variable progress. Such information as is available concerning the Schoop, Katadyn and Matzka processes follows.

### *A. Schoop process*

The two essential features of this patented process are the absence of any chemical treatment for sterilization or preservation, and the use of a very small quantity of sodium chloride in association with a special plant catalytic substance which are both added immediately after expression of the juice and prior to the storage of the juice at 34° F. until the various

changes have occurred. The function of the salt and plant material is to inactivate the oxidase and other enzyme systems which occur naturally in the juice. The former are presumed to be responsible for the change or loss of apple flavour on long term storage. It is claimed by the sponsors of the Schoop process that correctly processed apple juices will retain their fresh flavour in full intensity over a period of 2-4 years.

With regard to the enzyme action, Schoop regards the removal of pectin from the juice as likely to impair the flavour and nutritive value of the juice. The plant material added is therefore claimed to inhibit the action of naturally occurring pectase which would otherwise effect the removal of some of the pectic constituents of the juice. Finally, in consequence of Schoop refusing to allow  $\text{SO}_2$  or any chemical preservatives to come into contact either with the juice or with the plant to be used for processing, an alternative special method of sterilization of plant and bottles is included in the process.

The plant substance certainly induces a remarkable clarification in the freshly expressed juice, the solids forming into characteristic "flocks" which gradually settle to the bottom of the liquor. The process of clarification, however, is variable with respect to time and the juices must be kept in refrigerated vats at a maximum of  $33^\circ \text{F}$ . throughout the clarification treatment. The clear juice is still liable to ferment and refrigeration or sterilizing filters of special design are used for the stabilization of the juices for storage or final filtration into bottles.

### B. *Katadyn process*

A weak electric current is passed between two silver electrodes placed in the liquid to be sterilized. Minute quantities of silver are released into the liquid and these exert a sterilizing effect on the micro-organisms present. The method, together with the Matzka process, is an exploitation of the oligodynamic principle discovered by Von Nageli in 1893. Very slight amounts of certain metals exert powerful antiseptic influences, but although the amounts are small, there appears to be some difficulty regarding the position of the process from the health point of view in certain countries. Although there does not appear to have been any considerable development along these lines with fruit juices, the process is said to be used on the Continent in other branches of industry.

### C. *Matzka process*

This process has been used in America, Canada and on the Continent in connection with the production of various fruit juices.

Whereas the Katadyn and Electro-Katadyn processes make use of ionized silver at ordinary temperature, the principle of the Matzka process is to combine with the silver treatment the use of moderately high temperatures. The elevated temperature is claimed greatly to increase the oligodynamic action, and by a combination of the two, the temperatures which are found to be most effective can be reduced by  $15\text{--}20^\circ \text{F}$ . below those which would be necessary if the oligodynamic treatment were not included. The juices are passed between two tubes, one made of silver, the other of stainless steel, nickel or aluminium. These tubes are electrically insulated from each other. The water temperatures, one inside the silver tube, the other outside the stainless steel tube can be regulated to secure any desired temperature of the juice which, however, normally reaches  $120\text{--}150^\circ \text{F}$ ., varying with the product.

Under these conditions the silver passes into solution at the rate of less than 1 part per 100 million parts of juice.

A recommended procedure for apple juice production when used with the Matzka plant was given by Barbour, of the Toronto Research Foundation. Sound, clean fruit should be used, and the juice deaerated and fed to the Matzka plant by stainless steel pipelines. The flow of juice is regulated by control valves and meters, and the processed juice is filled right up to the necks of the bottles, leaving no head space. If the bottles are filled hot and capped immediately a vacuum of  $10\text{--}12\text{''}$  develops on cooling.

The sterilization of the bottles and caps depends on the size of the container. Matzka contends that the processed juice flowing from the special tubes retains a certain residual oligodynamic activity which it retains for about six hours and which is finally lost by the precipitation of the silver. With bottles of 24 oz. capacity or over, the juice remains hot enough

for a sufficiently long period for this activity to sterilize the bottles, but with smaller sizes it is necessary to pasteurize the bottled product for 20-30 minutes at a temperature a little below that at which the juice is processed. Crown corks were effectively sterilized by immersion in hypochlorite solution (500 p.p.m. of active chlorine) for 20 minutes followed by thorough washing. Alcohol may also be used for this purpose.

Some preliminary tests carried out by Arengo-Jones at Ottawa indicated that under certain conditions, the heat treatment given during the Matzka processing was sufficient alone to give stability to apple juice similar to that used by Barbour.

This was confirmed by thorough tests in which a tubular glass pasteurizer was constructed, Jones reaching the conclusion that "the process was one of simple pasteurization".

Spectrographic determinations of the silver content of apple juice, both before and after passing through the Matzka apparatus, proved "that little silver was being added by the Matzka process, certainly not sufficient, from any evidence obtainable, to effect the sterilizing action claimed for it".\*

A large Matzka plant was inspected by the writers in Holland in 1938. The product being bottled was tomato juice, as the cold sterilization process was preferred for apple juice. The cloudy tomato juice was deaerated under 55 mm. vacuum and was passed through the Matzka plant into hot sterilized bottles. The bottled juices were closed with crown corks and, in addition to the 6 seconds' holding at 65° C. in the Matzka tubes, were pasteurized in tanks of hot water for the following periods.

|               |    |    |    |    |        |
|---------------|----|----|----|----|--------|
| 30 minutes at | .. | .. | .. | .. | 70° C. |
| 10 "          | .. | .. | .. | .. | 60° C. |
| 10 "          | .. | .. | .. | .. | 45° C. |
| 10 "          | .. | .. | .. | .. | 25° C. |

It is obvious that the latter treatment constitutes a thoroughly effective holding pasteurization.

## 23. General considerations relating to flavour, sweetness, aeration, etc., of apple juices

### A. *Effect of cold and hot processes on flavour*

Whilst the final effect of the cold or hot process will vary according to the exact method used, there are certain broad generalizations that can be given. The chief difference is obviously the acquisition by the heated juices of a more or less "cooked" taste, resulting in the flavour of the juice being definitely reminiscent of an "apple pie" character. This "cooked" taste varies according to the actual pasteurization process. The method of slow pasteurization in bottles at 160° F. for half an hour gives poor results compared with the "flash" method, and the treatment of juices by the former method in cans is very inferior to the reception in the cans of flash pasteurized juices. Again pasteurization of very acid juices results in a much more cooked taste than in less acid products.

The effect of the pasteurization process on flavour is very much minimized by previous deaeration (30) and the final products are not noticeably "cooked" in taste, whilst processes such as the Matzka, with their lower pasteurization temperatures are said to cause only the very slightest alteration in flavour. Samples of American juices treated by this process, however, have been tasted at Long Ashton, and have possessed a definite cooked taste which, however, was by no means unpleasant. It should be remembered that when a direct comparison is being made between juice produced by the cold and hot methods, some difference in flavour may be due to the additional "polishing" filtration which is a feature of the cold process.

In many cases the fact that a juice has been pasteurized is not evident to a panel of amateur tasters unless a juice of similar composition, but treated by the cold process, is available for a direct comparison. When the differences are of this minor order there can be no doubt whatever that either product can be regarded as being of practically equal merit. Indeed, on account of the pasteurized juices being fuller in total flavour, heavier in "texture", and

\* From data kindly released by the author in anticipation of early publication.

possessing a more mellow and less acid character, there is often a definitely expressed preference for certain pasteurized juices as against similar juices which have been cold processed.

The cold process provides apple juice beverages some of which are remarkable for their fresh, delicately perfumed apple character. They are not so full-bodied, the acid character is in greater prominence, and the total flavour in the juice is less intense than in pasteurized products. The great appeal of the flavour of juices treated according to the cold process is the attractive, fresh apple aroma and flavour which forms a contrast to that of the hot processed beverages.

The two processes do not give comparable results with all types of apple juices. The thin character of the cold processed juices is especially noticeable in the more acid culinary and dessert varieties, where there is no great intensity of flavour in the fresh untreated juice. On the other hand the cider type of juices, with full bouquet and "body" reacts well to the cold process and the ultimate product is sufficiently flavoured.

It is not possible, nor is it desirable, to give recommendations relative to one or the other of the processes, but the above general remarks will be sufficient to enable a prospective producer to determine in a preliminary way what type of juice would best suit his intended market. There is certainly a place for both types, and the huge production of apple juice in Germany is actually divided fairly equally between the hot and the cold processes. In that country it was recently suggested that women and children have a preference for the pasteurized juice, whereas the experienced male consumer, influenced probably by this taste for wine, prefers the clean, fresh flavour of the cold processed products.

### B. Sweetness and acidity

Although it is known that apple juices possess valuable medicinal properties, they will be largely consumed as thirst-quenching beverages, and consequently the juice must be generally attractive and pleasant to drink. It has been shown that excess of sweetness and acidity can ruin the general character of the apple juice from its "drinking" point of view, although it can still be "sipped" without deficiencies in its composition being noticeable.

The actual analyses of apple juice in various parts of the world vary considerably. Germany and Switzerland produce sharp juices with acidities between 0.8 and 1.0% malic acid, this sharpness being balanced by a specific gravity of only 1.045-1.050. In Holland three distinct grades are defined:

|            |               |   |         |          |
|------------|---------------|---|---------|----------|
| Light type | 1.045-1.050   | : | acidity | 0.7-0.8% |
| Medium     | " 1.050-1.055 | : | "       | 0.8-0.9% |
| Heavy      | " 1.055-1.070 | : | "       | 0.9-1.1% |

The English juices on the market vary between heavy, cider-type juices with gravities of 1.045-1.055 and acidities below 0.45% and sharp culinary and dessert apple blends with acidities up to 0.75% but similar sugar content.

American juices vary greatly, but the general character is decidedly less acid than the English and Continental products. Many samples tasted in England have been too sickly sweet for the average English palate but the products have apparently sold well in the United States and Canada.

In concluding this reference to sugar-acid balance of apple juice it should be emphasized that whilst it is permissible to add sugar in some cases to increase the "body" of a juice, it is seldom wise to make this addition an appreciable one, especially if the sweetening is being done immediately prior to sale. The added sweetness will be distinguishable from that due to the natural sugars, and it will be many weeks before sufficient inversion of the cane sugar has occurred and before the extraneous flavour has diminished in importance. In any case, sweetening should be carefully controlled from the point of view of the drinking properties of the juice.

For the average English palate, it is considered, that the range of sugar and acid content should be as follows:

|                      |    |    |    |    |              |
|----------------------|----|----|----|----|--------------|
| Specific gravity     | .. | .. | .. | .. | 1.045-1.055° |
| Acidity (malic acid) | .. | .. | .. | .. | 0.50-0.75%   |

### C. *Aerated or still drinks*

At the present time pure apple juice is largely a "still" beverage. Whether or no it is desirable in the establishment of a new industry in a fresh area to depart from this position is largely a matter for local decision. The absence of the strong carbonation that characterizes mineral waters of the pure and synthetic type is likely to allow apple juice to develop a desirable individuality of its own. On the other hand account must be taken of the large consumption of aerated juices which indicates the popularity of this form of beverage. The still drink will obviously be preferable to athletes and should receive considerable support from the athletic world also on account of the ready availability of the energy-giving sugars, without the intake of an excessive volume of gas.

Carbonation is quite effective as a yeast inhibitor. Pressures of the order of 30 lbs. CO<sub>2</sub>/square inch have held juices sterile when the still beverages have fermented (30), but the pressure of CO<sub>2</sub> needed to provide a slight aeration (5-10 lbs./square inch) has no suppressive action on the yeast.

## OTHER FRUIT PRODUCTS

### 24. *Other fruit juices*

Various special processes are involved in the production of fruit juices other than apple and whilst exhaustive information will not be given the general outline of each process will be briefly indicated.

#### A. *Grape juice* (14, 39, 51, 65, 66, 85)

A dark, intensely coloured, highly acid juice is most successful in America, whilst in Germany white juices of slightly less acidity are also in considerable production. The flavour should be intense in order to appeal to the general public. The most popular beverages are made from Concord and other related (i.e. Labruscan) varieties in America and Riesling grapes in Germany. Blending is essential to produce the highest quality products and for this purpose Muscat is very useful for blending with more highly coloured and acid grapes.

The juice is expressed by means of a crusher consisting of two corrugated or fluted metal rollers rotating close together and towards each other. The grapes fall on top of the mills from a hopper, to which is also attached a stemmer to remove the stems.

Grapes for white juice should not be stemmed, as the stems give rigidity to the pulped mass during pressing and facilitate drainage. Basket presses are used in California and on the Continent, although the cloth and rack method yields larger quantities of juice.

The colour of the red grape is extracted by one of two methods. In the first place the skins and juice are heated at 160° F. for a few minutes and then pressed whilst still hot. The other method consists in lightly pressing the crushed, stemmed fruit; the juice is heated to 140° F. in a flash pasteurizer and is mixed with the partially pressed pulp and allowed to stand for 4-8 hours.

The juice is next pasteurized to effect the coagulation of the pectic and proteid compounds. The strained juice is heated to 180° F. and filled hot into sterile 5 gallon jars, which are sealed with paraffin wax and are then led to a refrigerating chamber so that the separation of the cream of tartar may take place as quickly as possible, although several months may elapse before this process is complete. The separated juice is racked from the crystalline deposit and filtered. In some cases no attempt is made to produce a clear product and consequently filtration is only sufficiently intense to remove solid materials. In other cases a brilliant product is obtained by means of one of the usual types of pulp or kieselguhr filters.

In America, juices are either pasteurized in bottles (185° F. for half an hour) or received in sterile bottles from the flash pasteurizer, whereas in Germany practically the complete output is stabilized by the cold process. The general character of the cold processed grape juice coming under the authors' notice was very attractive. In some cases the true vinous bouquet was present, the juices presenting all the attractions of high-class wine without the alcoholic content.

Cruess and Cash (39) give the following recommendations for canning grape juice :—

Heat crushed grapes at 160° for 5-10 minutes ; press hot in cider type press ; cool ; add diatomaceous earth ; filter ; deaerate ; blend with equal volume similarly treated Muscat juice ; raise acidity to 0.75-0.80% citric acid ; can in re-enamelled type L cans ; exhaust to 155°-160° F. and seal ; process at 160° F. for 20 minutes for 8 oz. to No. 2½ cans ; cool. The de-tartrating process is included if freezing equipment is available.

#### B. *Citrus juices* (14, 38, 58, 59, 60, 64)

The development of the citrus juice industry in the North American Continent has been phenomenal. The processes involve much attention to detail and cannot be given in full in this Communication, but the salient features will be briefly indicated.

The most important preserved citrus juice is grapefruit on account of its stable flavour which fact gives it a certain pre-eminence over orange and other juices which are still almost entirely sold in the fresh unreserved state.

Orange juice is now being canned, and although there is still some deterioration in flavour the advantages of a canned product are so appreciable that the sale of juice in this form is increasing.

Lemon juice is more unstable, the lemon oil being particularly liable to decomposition and staling which is accentuated by the high acidity.

The juice in all citrus fruits is contained in juice sacs which are separated by thin membranes and are surrounded by the inner and outer peel in which are the oil glands. Some of these tissues contain bitter substances which can deteriorate on long term storage. The oil is largely composed of terpenes such as limonene and these are responsible for the characteristic flavour of the fruit. The presence of oxygen is fatal to the preservation of the true fruit flavour and oxidation produces many stale and varied flavours. The various chemical constituents of the different tissues constitute grave difficulties when the extraction of the juice is being considered and the process has to be modified with this in view. Three general types are in use :—

- (i) The fruit is peeled and the juice expressed from the pulp in a continuous screw press.
- (ii) The whole fruit is halved and the juice extracted by a plunger type of press.
- (iii) The whole fruit is halved and the juice expressed by pressing the halved fruit against a revolving conical, ribbed or grooved extractor, or "burr". The process involves pressing and tearing and the optimum conditions for each must be sought in order that a minimum contamination with oil is effected.

The extracted juice is strained to remove coarse tissues or passed through centrifugal machines. Filtration is not practised to any extent.

The strained juices are deaerated and immediately flash pasteurized at 190° F., cooled to 175° F. and filled into citrus-enamelled cans. After inversion for a few minutes the cans are cooled, and are stored in cold storage.

#### C. *Soft fruit juices*

The marketing of the juice from soft fruits such as strawberry, raspberry, loganberry, blackberry and the white, red and black currants is complicated by two serious difficulties. In the first place, the natural juices are too sharp for direct consumption, the acidities ranging from 0.8% for strawberries to 3.5% for black currants. The sweetening needed to cover this acidity is such that a very heavy product is obtained, the sweetness of which detracts from the refreshing quality of the beverages. The acidity of some of the juices is so high that it is not feasible to reduce it by chalk to a suitable degree.

Secondly, fruit juices of this type do not always retain their flavour even when adequately protected against fermentation. For example, Charley has shown that fresh strawberry juice, preserved by Seitz E.K. filtration, completely lost its true fruit character after several months in bottle (27). The same is true, though to a lesser extent, for black currant juice, but raspberries and loganberries gave products which were recognizable as such after 12 months' storage.

American procedure for the limited quantity of soft fruit juice that is made is given by Cruess (38), and by Joslyn and Marsh (59). The fruit is crushed in a bronze crusher or apple mill and heated to 140°-160° F. either before or after pressing. If the fruit is difficult to press, it is heated before transference in the hot condition to the ordinary cider type of press. If the fruit is pressed first, the juice should be heated immediately afterwards to a temperature a little higher than that to be used for the final pasteurization in bottle. The juice is sometimes chilled and stored in glass or wooden vessels under refrigeration until needed for bottling. Alternatively, it can be filtered at once through any of the usual types of fruit juice filters, and canned after having been sweetened to the necessary degree.

The addition of sugar can be carried out in two distinct ways.

- (i) Sufficient sugar is added merely to cover the natural acidity. The final product will be a "sweetened juice" with a gravity of about 1.080.
- (ii) The sugar may be added up to 50% by weight on the finished syrup, the product in this case being a "syrup".

The sweetened juices can be consumed in a neat condition or with a slight addition of water, but the syrups need to be diluted with water to an extent corresponding to the sweetness of the syrup. In the first case, the final product will be about 90% pure juice, whilst the diluted syrup will contain only 10-20% pure juice. In most fruits the flavour in the diluted beverage is sufficiently intense.

Charley at Long Ashton developed in 1934-6 a completely cold process for the production of fruit syrups, which has been successfully placed on an economical basis, and such syrups were being produced commercially for the first time in 1936 (17, 22, 25, 26, 27, 28, 29, 36). The process is as follows:—the berries or currants are milled through a grater mill and received in 600-gallon slate tanks. Pectin-decomposing enzymes are added at the rate of 0.2% (2 lbs./100 gallons of pulped fruit). The enzyme should be chosen so that the pH of the fruit does not inhibit its rapid action. The most important result of this treatment is to induce a remarkable separation of tissues from the juice. The former collect in a hard layer on top of the practically clear juice, which is allowed to run away into collecting tanks. No difficulty is then experienced in pressing the fruit in the usual cloth and rack type of press. The duration of the enzyme action is limited by the onset of fermentation; for strawberries and raspberries 24 hours is the maximum time that can be allowed, but black currants often require 3-5 days to obtain the maximum effect from the enzyme. If fermentation ensues at a very early stage in the process, 200 parts per million of  $\text{SO}_2$  may be added to the pulp without seriously reducing the enzyme action. The enzyme treatment increases the yield and colour of the juice, and in the case of strawberries and raspberries produces a straightforward pressing manipulation in place of the difficult procedure which results from pressing untreated fruit.

The juices are centrifuged into enamelled mixing tanks where solid cane sugar is quickly incorporated in the cold until the sugar content reaches 50-55% by weight, the volume of the juice being increased to about 1.7 times its original volume. At this stage it is essential to raise the acidity of strawberry syrups, and others where necessary, to 1.1% citric acid by weight. It has been found that even when a brilliant syrup is preserved with the maximum dose of preservatives in a sterile jar, fermentation will ensue unless the acidity is raised to 1.1%. This fact is of the utmost importance for the storage of fruit syrups by the cold process. The acid is added in the form of a concentrated solution.

The preservative preferred is  $\text{SO}_2$  (350 p.p.m.) which is added as potassium metabisulphite (K.M.S.) which contains approximately half its weight of  $\text{SO}_2$ . Sodium benzoate is not so certain in its action and gradually causes distinct browning in the red and crimson colours.  $\text{SO}_2$  bleaches the colours to a considerable extent, but for the standardization of colour in both cases some permitted food colour is needed.

The cloudy syrups are easily filterable through the plate and frame types of filters, using a somewhat coarse grade of filter aid. The brilliant syrups have been shown to be practically sterile and are stored either in large slate or glass-lined vats, or in glass gallon jars.

It has not yet been found possible consistently to prevent the deposition of further pectic and proteid substances, even by protracted initial enzyme action. The filtered syrups

on occasion become cloudy, but, if filtered a second time after 4 months' storage, the product remains permanently bright. There is no essential need to filter the cloudy syrup when it is made. In this case one filtration only is necessary.

The syrups are suitable for a wide variety of household purposes, such as jellies, cake filling, confectionery, etc. For cold milk shakes, the acidity mentioned above is quite satisfactory, but the very high acidity of black currant juice should be reduced to such a figure as will give the necessary acidity in the syrup. It is possible to buffer the syrups by the addition of 4 fluid ounces of saturated sodium citrate solution per gallon of syrup, in which case the syrups may be added to milk at 195° F. without curdling.

The reduction of titratable acidity, which to some extent is correlated with the curdling phenomena, can only be effected if the juice content of the syrup is simultaneously reduced. For hot milk shakes, in which no buffer is used, the acidity should be 0.6%, in which case the juice content is lowered to 35% for strawberry and lower figures for the more acid fruits by the addition of sugar syrup.

Juices are prepared commercially in England from the cold process syrups by measuring 1½ fluid oz. of syrup into "split" (i.e. 6½-7 fl. oz.) bottles and filling with aerated water. These products are remarkable for their fresh fruit character. They can be satisfactorily produced from syrups that are over 2 years old and still retain the aroma and flavour associated with the fresh fruit. Preservation is by means of 70 p.p.m. of SO<sub>2</sub> or 120 p.p.m. of benzoate of soda, but the former is generally employed. The efficient sterilization of bottles is an essential feature of the process.

National Mark schemes controlled by the Ministry of Agriculture and Fisheries, have been introduced in England to standardize the composition and quality of fruit syrups and aerated fruit juices.

#### D. Squashes (23)

Cloudy products can be made from soft fruits, by separation of the skins, seeds and hard tissues in some form of fruit sieving machine. The pulp is mixed in sugar syrup until the squash registers 35° Brix, the acidity is adjusted to 1.5-1.8% citric acid by weight and the product preserved as for syrups. It is essential that the raw material should be free from fermentation or mould growth, as no filtering process can be used to reduce the number of micro-organisms.

#### 25. Cider

Cider is the fermented juice of the apple, and the term should not be applied to "sweet apple juice" in which no alcohol is present.

This beverage is made in very large quantities in France, Germany and England, the average annual quantities being as follows:

|         |    |    |    |    |    |                       |
|---------|----|----|----|----|----|-----------------------|
| France  | .. | .. | .. | .. | .. | 630 million gallons.* |
| Germany | .. | .. | .. | .. | .. | 6     "     "         |
| England | .. | .. | .. | .. | .. | 20-25     "     "     |

In France and England cider is practically entirely made from special cider varieties of apples of which there are literally hundreds of different sorts. These apples differ from culinary and dessert varieties by virtue of their slightly higher sugar content, their lower acidities, and, of prime importance, their much greater astringency (so-called "tannin" content). This last mentioned constituent is responsible for the slightly bitter, astringent taste of the true type of cider, and also confers a degree of body and character to the product that is not attained by any other means.

The average analyses of cider, culinary and dessert apple juices are given in Table 4 and indicate the deficiencies of the non-cider varieties of fruit. These deficiencies in the juices are to some extent transferred to the finished product, for ciders made by ordinary methods from culinary or dessert apples lack a certain body and roundness of flavour that is a characteristic of cider made from vintage fruits. Whilst the

\* This output of fermented cider is used either for direct consumption or for distillation into cider brandy (calvados) or commercial alcohol.

acidity of the juice is readily adjustable, the increasing of the tannin content is not so simply achieved, and although maceration with bittersweet pomace is one way of conferring body on culinary juices, this is not practicable where no cider fruit is grown.

#### A. *Recommended varieties* (4).

The following list of cider varieties has been recommended for extensive planting in England. For Dominion or Colonial planting, the varieties should be chosen with the particular local needs of the apple growing industry in mind. Only bitter fruits should be planted if it is intended to use the cider fruit for blending with cull types of local grown fruit.

##### (a) High grade vintage varieties

|                               |   |                                                                                                     |
|-------------------------------|---|-----------------------------------------------------------------------------------------------------|
| Cap of Liberty (bitter sharp) | } | These are susceptible to canker, but do produce good trees where local conditions are satisfactory. |
| Foxwhelp                      |   |                                                                                                     |
| Kingston Black                |   |                                                                                                     |

##### (b) General list

| <i>Sharp.</i>       | <i>Sweet.</i>    | <i>Bittersweet.</i> |
|---------------------|------------------|---------------------|
| Crimson King.       | Eggleton Styre.  | Bulmer's Norman.    |
| Dymock Red.         | Sweet Alford.    | Dabinett.           |
| Fair Maid of Devon. | Slack-ma-Girdle. | Ellis Bitter.       |
| Reinette Obry.      |                  | Knotted Kernel.     |
|                     |                  | Royal Wilding.      |

##### (c) Supplementary list of bittersweet varieties.

|                     |                     |
|---------------------|---------------------|
| <i>Early :</i>      | Belle Norman.       |
| <i>Mid Season :</i> | Tremlett's Bitter.  |
|                     | White Close Pippin. |
|                     | Yarlington Mill.    |
|                     | Chisel Jersey.      |

For general supplies of bittersweet fruit Dabinett, Knotted Kernel and Yarlington Mill are very useful varieties.

The cider trees are slow maturing, but can be head-worked on orchard trees of unprofitable varieties, and under these conditions make much quicker growth.

#### B. *Manufacturing processes*

It is outside the scope of this communication to give full details of the various manufacturing processes, but there follows a general review of the salient features of cider-making in the three countries mentioned (35).

(a) France (84). The apples on reaching maturity are washed, milled and the milled pulp allowed to macerate for 4-12 hours. The macerate is pressed in hydraulic presses, and the juice pumped to large shallow vats with a considerable area exposed to the air. Keeving is carried out in the vats for 3-8 days, during which an extensive coagulation of pectic and proteid substances occurs and the solids form top and bottom deposits from which the juice is racked away for fermentation. The latest process is to retain some of the keeved juice in an absolutely unfermented condition by storage in large bitumen-lined, concrete vats at 0° C. and to allow a further quantity to ferment to dryness (i.e. complete absence of sugar). The two products are blended later before being filtered and bottled. The earlier process, which is still largely used, is to rack the cider from the yeast deposit at various times to prevent too rapid fermentation and to maintain the bulk of the cider in a medium sweet condition. Storage of this product is usually effected by the use of large concrete vats lined with various forms of lining or enamel (i.e. Ebon, Gaschell, Mamut Ventur, Étanchit). The cider can be artificially carbonated prior to bottling, or the pulp filtered or racked product can be bottled in the middle of spring and allowed to develop a secondary fermentation which will create a natural aeration with retention of the aroma and bouquet derived from the fermentation process, together with a deposit of yeast and amorphous organic material. If the deposit be excessive, it must be disgorged by the authentic champagne process. The flavour of the champagne cider is superior

to the ordinary cider but on account of the expensive nature of the former process it is not now used to any considerable extent.

The normal French cider possesses a composition varying between the following limits: gravity 1·020-1·030; acidity 0·30-0·55%; tannin 0·15-0·25%; alcohol 4·5% (by weight).

(b) England. The cider apples are always shaken from the trees, as in France, and consequently it is necessary to wash the fruit. Maceration and keeving are no longer practised except in isolated cases, the freshly expressed juice being pumped straight to the fermenting vats. The natural yeasts alone are responsible for fermentation and the usual practice is to allow fermentation to proceed at a steady rate until a gravity of 1·008-1·005 is reached. Racking is adopted to slow down the yeast action where necessary and the super-centrifuge is being increasingly used for this purpose. The machine can also be used to great advantage for the preliminary clarification of the cider previous to filtration, and for the removal of lees from the ciders which have completed their main fermentation. Storage in concrete vats is now in general use and satisfactory linings are available to prevent the acquisition by the cider of any flavour from the vats.

The stored cider is sweetened with boiled cane sugar syrup, filtered through pulp filters, and usually sterilized by the Seitz E.K. filter which has practically revolutionized the methods of bottling since its introduction in 1926. Providing the racking process has been efficiently carried out, it is sometimes possible to bottle a stable cider with the use of the pulp filter only, but for hot climates the sterilizing filter or pasteurization in bottles is advisable.

A small quantity of naturally sweet cider is bottled. In this case the cider is passed through the centrifuge or filter when the fermentation has reduced the gravity to 1·025-1·030. The clarified cider is stored in wooden or other vessels and is merely filtered, carbonated and bottled when needed for consumption. Ciders of this type, which are naturally conditioned in bottle, are special products of certain farm cider makers in the south-western counties, especially Somerset. Such ciders rank among the richest and finest products obtainable.

Increasingly large quantities of surplus culinary and dessert apples are finding their way to the cider factories. Fermentation is usually very fast in these juices and every effort is made to extend the fermentation period over at least a fortnight.

Dry cider is being sold in greater quantities on account of its reputed effect in rheumatic cases. Culinary and dessert fruits, by reason of their rather hard flavour, do not lend themselves to the production of this type of cider.

(c) Germany. The development of apple juice has practically stopped the production of a medium sweet cider and the great bulk of the cider sold is practically dry. The special feature of interest in the German industry is the extensive use of pure yeast cultures for the fermentation. The fresh juice is centrifuged and inoculated with a 2·5% culture of a special wine yeast such as *Zeltingen*, *Steinberg*, *Waldenberg*, or *Riesling*. The completely fermented ciders are allowed to stand on their lees for several months before being filtered and prepared for sale. The slightly harsh after-taste of ordinary dry cider is thus replaced by a smooth, vinous character which is reminiscent of dry wines. Experiments carried out with the use of these yeasts with English apple juice indicate that a slight but definite improvement of flavour may be expected.

## 26. Fruit wines (37, 43, 44)

Wines with 8-14% of alcohol by weight are capable of being produced from all sorts of fruit. Apple wine is not a satisfactory product, especially when made from market varieties of apples, but excellent wines can be made from strawberries, raspberries, loganberries, and also from black currants and cherries. Cruess, Marsh and Mendels (44) give the following recipes for various wines.

### A. Berry wines (U.S.A.)

Crush berries and add 8 oz. K.M.S. per ton. After 2 hours add a starter of 2·3% yeast culture. When fermentation has reduced sugar to one-third or one-fourth of its original content, press out the juice in the ordinary cloth and rack press. To the juice add, for a dry wine,

15% by weight of sugar, but 25% for a sweet wine. Ferment to completion and allow to stand; rack off into clean casks and allow to clear; filter into steamed casks for maturing period.

Sweet wines were preferred to the dry type.

#### B. *Cherry wine*

The cherries were crushed without disintegrating many seeds, heated to 180° F., pressed, cooled and the sweetened juice fermented with pure yeast. An alternative method was to crush the cherries, add 8 ozs. K.M.S. per ton, ferment the pulp 3 days with pure yeast, and press out the juice and ferment it in casks closed with a fermentation lock.

#### C. *Apple wine*

Cruess states, "We shall call it hard cider and forget the word wine!" The product is made as for cider production with the addition of the necessary sugar at some stage of the process.

#### D. *Berry wines (English)*

Charley (17, 24) has investigated the manufacture of wines by the use of surplus fruit which had commenced to ferment and was consequently of little use for syrup production. It was shown that a considerable reduction of acidity was needed for the production of palatable products. In many cases the juice from the fermented fruit was diluted with twice its volume of water, and the sugar needed for alcohol formation added in separate portions as fermentation proceeded.

(a) Strawberry wine. Strawberries produced a remarkably good wine, with a very characteristic light brown sherry aroma and flavour. The wine matured up to three years and developed a very mellow and intriguing flavour.

(b) Loganberry wine. Loganberry wine developed into a full-bodied, luscious port type wine, in which the fruit character was retained.

It was shown that "stuck" fermentations are largely due to nitrogen starvation and that by the addition of ammonium phosphate up to 7 ozs./100 gallons they could be made to recommence to ferment. Pure white cane sugar was the most satisfactory for sweetening.

Commercial production of the last two wines has been successfully tried in England, but owing to the very cheap price of Empire wines there would not appear to be much opportunity for the development of these two English fruit wines.

#### E. *Loganberry wine (Canada)*

Loganberry wine has achieved a certain importance in the valleys in British Columbia where this fruit is widely cultivated. Newton of the Dominion Laboratory of Plant Pathology has studied the question from the micro-biological point of view. Newton and Edwards (72) have shown that wild yeasts are more sensitive to chemical preservatives than the pure wine yeast type, and that the lethal efficiencies of preservatives towards both yeasts increase with the alcohol content. Thus, the sulphuring of the fruit most probably exerts a selective influence on the flavour of the juice, suppressing the wild organisms thus allowing the pure yeasts to develop.

### 27. **Fruit brandies**

Only three fruits are widely used for this purpose, namely, cider apples in France for cider brandy ("calvados") production (84), plums in Roumania for plum brandy, and cherries in several European countries for the manufacture of "kirsch".

In France seven million gallons of 100% alcohol are produced annually from apples. Although it is not known what proportion of this is consumed as brandy, it is certain that very large quantities of potable spirit are produced. Roumanian peasants make nearly thirteen million gallons per annum of 25% alcohol spirit from plum wine in 52,000 small domestic stills.

The upright French condenser, fitted with various forms of baffle plates, is in general use. The spirit is first obtained in a 50% strength, and is then rectified to 95% alcohol, and stored and matured in this condition.

Very attractive cider brandies have been made at Long Ashton from cider and culinary apples. Morgan Sweets, a prolific apple of the sweet type, was converted into a fine brandy of 60% alcohol. Maturing was continued for 3-4 years.

## **28. Cider vinegar (12, 14, 31, 42, 56, 77)**

Vinegar made from cider is in almost universal use in the North American Continent, but elsewhere it is not produced to any extent. The intermediate product, i.e. cider, is made in the normal way with the possible exception that fermentation may be speeded up by fermenting in a warm atmosphere. To regularize the fermentation and obtain the maximum production of alcohol, it is recommended to use a pure wine yeast starter for the initial fermentation of the juice. The completely fermented product is allowed to stand for a short while, and is racked from the lees and prepared for its passage through the generators. Alcohol is converted into acetic acid, the essential principle of vinegar, by the agency of the acetic bacteria, which need regulated supplies of oxygen for their optimum development. The upright generator provides a means whereby the maximum surface of fermented cider (5% of alcohol) is exposed to the air in the presence of the bacteria. The central portion of the generator is packed with beech wood or rattan shavings. Near the bottom of this portion is a series of adjustable openings for the admission of air. Above the compartment containing the shavings is a tilting trough into which the fermented cider is filled. The action of the trough is to distribute the cider equally all over the area of the beech shavings. As the cider trickles over the shavings, which have been previously impregnated with vinegar containing active acetic bacteria, the alcohol of the cider is oxidized by the agency of the bacteria and atmospheric oxygen into acetic acid with the consequent formation of cider vinegar. The management of a vinegar generator is a matter of attention to detail and experience is a valuable asset in this connection. The alcoholic liquor can be run either once or twice through the generator. In the "one run" process it is first mixed with twice its volume of fresh vinegar, whilst in the second case the cider is run through the generator once to produce a vinegar with about 3% acetic acid, followed by a second passage to complete the conversion of alcohol into acetic acid.

The control of temperature around the optimum of 85° F. is of the utmost importance. If the temperature rises the rate of flow of juice and intake of air must both be reduced. If, however, the temperature falls it may be raised by increasing the flow of liquid and by admitting a large volume of air through the intake at the bottom of the central compartment. Excessive flow of air should be carefully avoided, as this causes loss of alcohol and consequently of acetic acid, both by evaporation and oxidation beyond the acetic acid stage to CO<sub>2</sub> and water.

The harsh flavour of the fresh vinegar is replaced by a mild and pleasing character by maturing in wooden vats for six months. Smaller bulks age more rapidly than larger quantities.

Vinegar can be clarified by filtration through the ordinary type of cider filter, but corrosion of metal is much more rapid than with cider (33). Silver-plated metal surfaces are desirable, or some of the new forms of hard rubber are satisfactory. Filtered vinegar often becomes cloudy on account of the growth of a film of acetic bacteria. This can be prevented by pasteurization at 150° F. for a few seconds.

## **FURTHER PROCESSING OF FRUIT JUICES**

### **29. Concentration of fruit juices**

Fruit juices can be considered as water solutions and suspensions of sugars, acids, and a number of other chemical compounds such as tannins, pectin and the organic chemicals responsible for the flavour and aroma of the juice. For reasons of economy in transport or in storage it may be desirable to reduce the bulk by removing as much as possible of the solvent (i.e. water) by converting it either into steam or ice and removing it in one or other of these

states. Both processes are used and are known as the evaporation and freezing methods respectively.

Fermentation is always completely inhibited in concentrated products whose sugar or soluble solids content is in excess of 68%, but in many cases where the concentrate contains a high percentage of acid, stability is achieved with 60-65% soluble solids. Concentrates which satisfy these conditions may be stored safely and without the use of preservatives. Considerable quantities of Canadian concentrated apple juice with 58% soluble solids are safely transported annually to England in wooden casks.

The degree of concentration essential for safe storage of the product naturally depends on the soluble solids content of the fresh juice. For apple, a concentration of 1 to 6 is usually

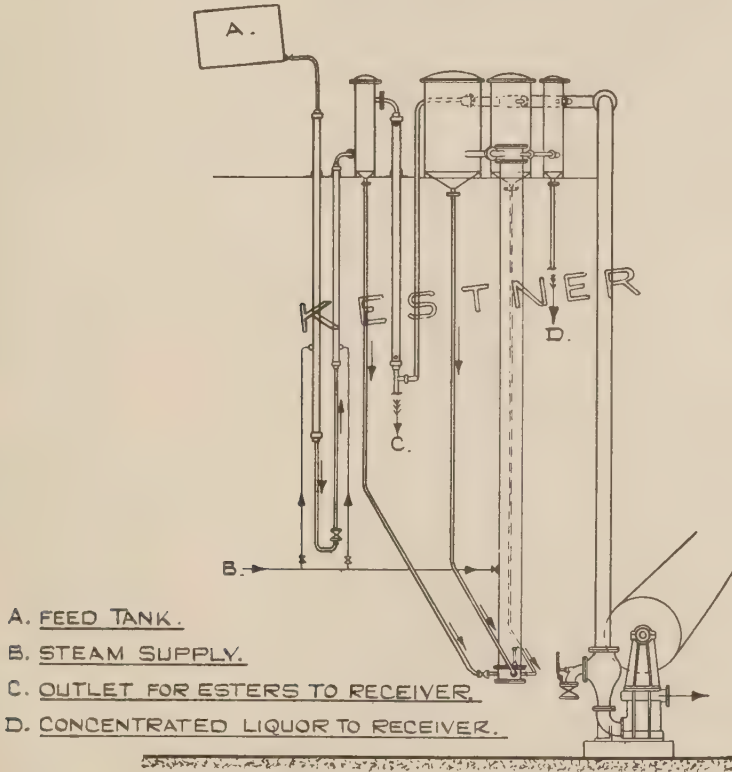


FIG. 45.

Vacuum concentrator for fruit juices (with return of volatile fractions).

satisfactory, but for soft fruits such as strawberry and raspberry, a ten-fold reduction in volume is generally necessary. Much difference of opinion exists as to the advisability of allowing a controlled fermentation to commence in the juices prior to their concentration. Some removal of pectin is essential to prevent the formation of a jelly from the concentrated product, but it is probable that the use of enzymes is a superior method to that of allowing the pectin to be removed by a short fermentation. This latter process, by reducing the sugar content of the juice involves a more considerable removal of water in the final process to ensure stability.

### A. *Hot process* (15, 17, 52, 75)

The concentration process originated by boiling the juice in heated open pans, or even by utilizing the heat of the sun, but modern plants are all designed to evaporate under high-vacuum-low temperature conditions. The highest degree of vacuum that is normally obtainable enables the juice to boil at 35° C. whilst several other types of apparatus work at 40-50° C. A very wide variety of mechanical devices are used to supply the heat to the juice in the most efficient way, while obviating the possibility of overheating which would cause the juice to acquire a cooked taste. The heating devices are known as callandria and are incorporated in a single

unit with the boiling chamber and the vacuum and condensing systems. The vacuum can be maintained either by the dry or wet pump method.

Commercial tests have been carried out by Charley on a Kestner triple circulation evaporator (Fig. 45), in which the juice is drawn up 3 evacuated stainless steel tubes in succession. The juice takes the form of a film, evaporation is very rapid, and working temperature of about 50° C. was not sufficient to affect adversely the flavour of apple juices, of cider and culinary varieties, nor of black currant and raspberry juices. Strawberry juice, however, proved more difficult to process and lost some of its freshness during the evaporation treatment.

One disadvantage of the hot process of concentration is that the effect of heat on the flavour of the juice is increased by the very high acidity which is reached towards the end of concentration. Acidities between 5-18% of malic or citric acid are possible, and under the conditions of evaporation are able to cause detrimental changes in the flavour.

### B. *Freezing process* (21, 70)

It has long been the practice in certain districts in England to place small casks of fruit wine out of doors on nights when very low temperatures are expected, and to draw off later the liquor from the



FIG. 46.

Concentration of fruit juices by freezing (cake of frozen juice prior to centrifuging : Krause method).

central core. The soluble portions of the wine would be concentrated and in some cases a sweet liqueur type of product was obtained. This simple example affords an idea of the principle of freezing concentration and several different processes have been evolved to carry out the ice formation and its subsequent separation in a controlled manner. The processes which are concerned with modern concentration technique are those of Monti in Italy, Krause in Germany and Heymans in America. Of these, chief interest attaches to the Krause process which is in commercial use in Germany. The juice is contained in a special cell holding 250 litres which is immersed in a refrigerating mixture. The conditions of freezing are such



FIG. 47.  
Concentration of fruit juices by freezing : continuous ribbon of frozen juice prior to removal of concentrated juice in continuous press : Krause method.

that the ice is formed in a regulated manner, to facilitate the drainage of the concentrate away from the ice matrix. The cell is then removed (Fig. 46) to a lagged centrifuge and whizzed until the product ceases to flow away. By the provision of a series of freezing tanks, the process can be worked continuously. A more recent process introduced by Krause involved the continuous freezing of the juice in the form of a "ribbon" (Fig. 47) and the removal of the concentrated juice by continuous presses.

Bilham (11), who has subjected the process to a stringent examination, makes the following interesting statement "With wages at 1s. 3d. per hour, electricity at 1d. per unit, cooling water at 3d. per thousand gallons, the prime cost of concentration is about 1d. per gallon of the finished product, using three stages." The plant (examined in Germany) has a capacity of 1,250 litres of original juice per hour.

The method involves very little loss through entanglement of the fruit product with the ice and the products are of very high quality. To quote Bilham, "The superior flavour of the juices as compared with those concentrated by heat, and the economic advantages of the reduction in bulk and the removal of the necessity for storage at very low temperatures, make them very desirable products. The process involved may be expected to be improved and refined and as knowledge of the requirements necessary to produce concentrates better in flavour and storage qualities increases, a more general adoption of concentration by freezing may be predicted."

### 30. Freezing of fruit juices

On many occasions freezing has been proposed as the ideal method of preserving fruit juices, but as yet no commercial scale plant has been successful. Many apparently insuperable obstacles are concerned with problems of marketing and distribution and the rapid deterioration of the juices on thawing has prevented their widespread acceptance. Some general details of the processes in use are given by Tressler and Ever (79).

#### A. *Orange juice*

Quick freezing is desirable and many different methods have been tried in commercial practice. Burton describes a method used in Florida in 1931 in which the juice was frozen to a slush under vacuum (27 inch) in vertical direct expansion ice cream freezers. The slush was forced out by nitrogen pressure into cartons which were filled and closed. The freezing was then completed in a blast of cold air at  $-10^{\circ}$  F. The storage temperature of the frozen product was maintained at  $0^{\circ}$ - $10^{\circ}$  F.

#### B. *Grape juice*

Joslyn gives the following details: "The juice is strained and precooled by a brine coil. The precooled juice is maintained at a temperature of about  $30^{\circ}$  F. for 24-30 hours to ensure partial clarification by settling and removal of some cream of tartar. The partially cleared, cold juice is barrelled and placed at  $0^{\circ}$ - $10^{\circ}$  F. and allowed to freeze, leaving an air space of 10% to allow for expansion".

#### C. *Apple juice*

This juice may be preserved either by slow or quick freezing, although the latter method is preferable. Enzyme treatment is desirable to remove the pectic constituents of the juice.

#### D. *Pineapple juice*

Chace and Poore (16a) reported in 1931 that pineapple juice was satisfactorily preserved by freezing and that the quality of the product remained unimpaired for 12 months.

### 31. Spray drying of fruits and fruit juices

In very recent years processes have been devised for reducing whole fruits or fruit juices into fine powders of a stable nature (75). The exact procedure varies with the type of fruit and

whether the fruits themselves or the expressed juices are being processed. In the former case, the fruit is disintegrated and fed by gravity to one or two dispersers in order to secure a fine, free-flowing cream. The liquid product is pumped into the spray drying plant where a centrifugal atomizing gear is used to inject the creamed fruit into the drying room in which the drying is effected by a current of hot air. In the drying chamber (Fig. 48) the finely atomized particles of fruit are dried instantaneously and the powder collected from the base of the chamber. The air used for supplying the heat contains a small amount of entrained powder which is separated out by means of the centrifugal dust separator.

It has been found possible to dry whole oranges, lemons, raspberries and black currants, as the pips, etc., are all finely divided in the initial disintegration. For a completely soluble product, expressed juice only should be dried, and the final product can then be used for jellies and general flavouring purposes.

The temperature in the average installation rarely exceeds 70° C.; the duration of the heating is a matter of seconds only and it is stated that the cooked taste is reduced to a minimum.

## BY-PRODUCTS

### 32. By-products of the fruit juice industry

The presscake remaining subsequent to the expression of the juice from any milled fruit possesses a certain value. The position with respect to the apples and soft fruits will be considered separately.

#### A. *Apple pomace*

The presscake from apples is known as "pomace". It usually contains about 60% of moisture after a second pressing, but it is generally not possible to attempt to remove further quantities of this juice by hydraulic pressure. The solid tissues comprise the whole of the apple except the greater part of its juice and include carbohydrates, fibre, ash and protein substances. The composition of a typical pressed apple



FIG. 48.  
Spray drier (Kestner type).

pomace in comparison with wet brewer's grain and mangolds is given below (6) (all figures given as percentages) :

|                                 | Pressed apple pomace. | Wet brewer's grain. | Mangolds (medium quality). |
|---------------------------------|-----------------------|---------------------|----------------------------|
| Water .. .. .                   | 76.05                 | 76.2                | 88.0                       |
| Fat, etc. (Ether extract) .. .. | 1.12                  | 1.7                 | 0.1                        |
| Protein .. .. .                 | 1.53                  | 5.1                 | 1.2                        |
| Crude Fibre .. .. .             | 4.42                  | 5.1                 | 0.9                        |
| Ash .. .. .                     | 0.71                  | 1.2                 | 1.1                        |
| Carbohydrates .. .. .           | 16.17                 | 10.6                | 8.7                        |

The figures indicate that the feeding value of wet apple pomace is distinctly higher than that of mangolds, and whilst its protein content falls below that of brewer's grain, the carbohydrate percentage is in favour of the apple product.

Two main uses for the pomace have been discovered, namely as a source of pectin and as a stock feed. These will be discussed separately.

(a) Pomace as a source of pectin (3, 6, 34, 76, 81, 86). The pectin constituents in the whole apple are largely left behind in the pomace when the juice is expressed. It is usual to dry the pomace until the moisture content falls below 12% in which condition the dried product can be safely kept over a long period and the pectin extracted when desired. For drying purposes rotary machines are now in favour, although kilns similar to those designed for hops and malt have been used with success. Two types are in use, i.e. those in which the whole drum of the drier rotates and the pomace is dried in the atmosphere of steam, or machines in which the pomace is mechanically tossed over a series of steel pipes carrying steam at 80 lbs. pressure (Fig. 49). The pomace itself should never reach a temperature higher than 160° F. on account of the liability to over-heating and consequent deterioration in quality and quantity of pectin.

Dried apple pomace usually contains 8-14 % crude pectin as determined by the alcohol precipitate method, but this figure does not bear any definite relationship to the value of the pectin as a setting agent for jams. A complete assay of an apple pomace should include a series of jelly tests using the pectin extract for the setting of standard quantities of sugar and acid and subsequently determining the strength of the jelly.

The production of pectin from pomace on a commercial scale is limited to a few large producing units and detailed methods of large scale production are not readily available. Rooker (76) gives the following method :—The pectin is extracted from the pomace by acidified water under pressure at 100° C. for  $\frac{1}{2}$  hour. The extract is freed from starch by diastatic action, and decolorized and clarified by filtration through purified absorbent charcoal and diatomaceous earth in a plate and frame filter. The clear liquor is evaporated in vacuo until the pectin strength reaches about 3%. This product is usually very viscous and straw coloured. It is sold either in bulk or in domestic sized bottles for the setting of jams and jellies.

American plants produce a powdered apple pectin which is in considerable demand for the medical treatment of colitis and related disorders. Special purification of the pectin liquor is necessary in order that the dried product may possess satisfactory features with respect to moisture absorption, colour and flavour.

The manufacture of liquid or solid pectin is entirely a matter for specialist production and should not be attempted unless this is appreciated.

There is also a danger that the market may become glutted with pomace, as more drying machines are installed. In 1933, Barker (6) quoted the price of dried pomace in England as ranging from £5 to £12 per ton. In 1938, the highest price obtainable for high grade pomace was £7 15s. per ton.

Very little information is available regarding the pectin content of pomaces from different varieties of apples. The only generalization that can be even approximately made is that pomace from cooking and dessert fruits is somewhat richer in pectin than that from cider fruit.

(b) Pomace as a stock feed. The limitation in the demand of pomace for pectin extraction has reintroduced the neglected subject of the use of pomace as a feed for animals. Practically no scientific information is available in England, but the position there in 1933 is summed up by Barker (6) as follows :

In some districts, there is local feeling against the use of pomace as a feeding stuff for live stock of any kind, and it is discarded altogether. This appears to be due, in some instances, chiefly to ignorance of its value : in others, possibly, its misuse has led to unfortunate experience. In other localities, where it is not made use of for feeding purposes direct, pomace is sold to other cider-makers who are equipped with drying machines. Very widely, however, it is utilized

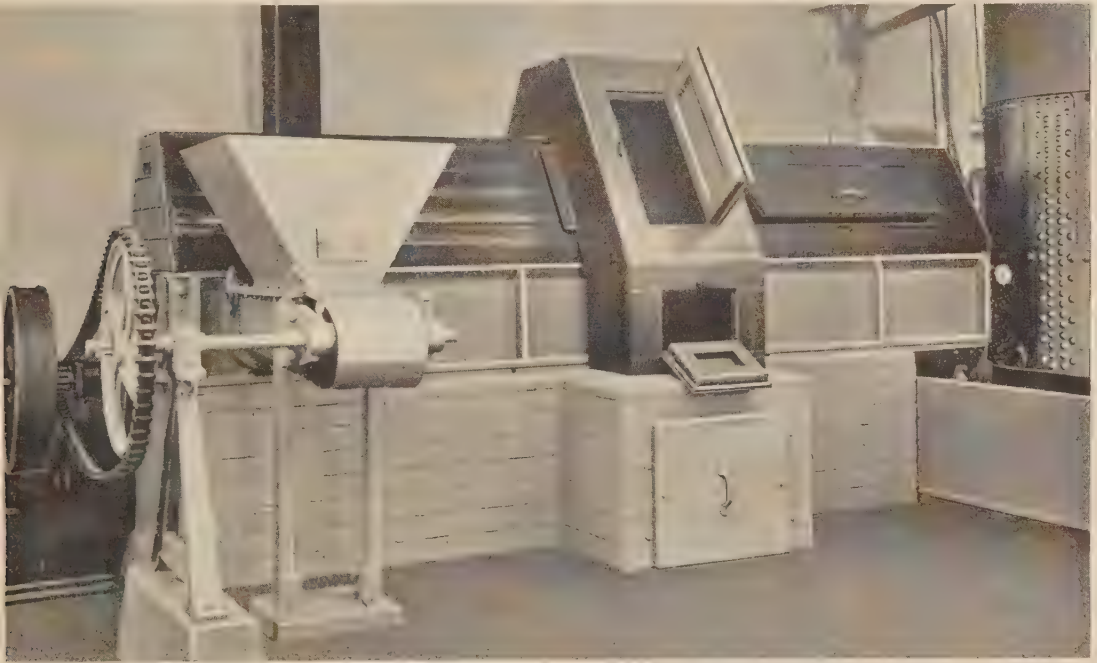


FIG. 49.  
Apple pomace drier (Simon type).

by farmers direct in the undried state, and in such instances there is considerable variation in practice.

Usually the undried pomace is fed to dairy cows. The quantity per head per feed varies widely, ranging generally from 10 lbs. to 30 lbs. Many farmers spread it on pastures as being a cleaner and more satisfactory method of handling, and in such instances the consumption per cow cannot be very closely estimated. There is fairly general agreement as to its utility subject to the qualifications that there must be no over-feeding because of the risks of tainting the milk and causing scouring, and that the material should be used fresh before acetic fermentation has fully set in. Its food value is rated by some who utilize it in mixed rations (as, for example, in conjunction with hay), at about twice that of roots. When used in this way, the inclusion of sharps or middlings in the production ration is recommended.

By some it is also fed to store cattle and to pigs ; for the latter it is sometimes used to replace meal in the slop.

As regards dried pomace for feeding purposes, it is generally included in compound cakes and foods, serving as a filler with more concentrated nutrients. In at least one area, some attention has been given to its use direct with apparently highly successful results. In such instances it is held to be a useful ingredient of any properly balanced ration for dairy cows, provided that it does not exceed about one-sixth of the total ration. It can replace or supplement sugar-beet pulp, and should be reckoned as a low-grade cereal. As a part of a fattening ration for winter-fed cattle, and as a ration for sheep folded on roots, it has also been used with success, the quantity used being considerably larger in proportion than that for dairy cows.

A great deal of scientific work has been carried out in U.S.A. on this question. Lindsey, Beals and Archibald working with dairy cows, concluded that dried apple pomace was but slightly inferior to dried beet pulp or corn meal. Walton and Bidwell (83), again working with dairy cows and using soaked pomace obtained evidence that "pound for pound of dry matter consumed the moistened apple pomace seemed to be slightly more efficient as a milk producer than good corn silage". Holdaway (55a) concludes that one ton of dried apple pomace is equal in feeding value to 3 tons of corn silage.

Knott, Hodgson and Ellington (62) have investigated the matter more recently. The analyses of the various feeds used by the workers for the experiments are reproduced below:—

CHEMICAL COMPOSITION OF EXPERIMENTAL FEEDS

| Ingredient.         | Moisture<br>per cent. | Crude<br>protein<br>per cent. | Crude<br>fibre<br>per cent. | Ether<br>extract<br>per cent. | N-free<br>extract<br>per cent. | Ash<br>per cent. |
|---------------------|-----------------------|-------------------------------|-----------------------------|-------------------------------|--------------------------------|------------------|
| EXPERIMENT I.       |                       |                               |                             |                               |                                |                  |
| Alfalfa hay .. ..   | 13.01                 | 18.42                         | 12.24                       | 4.56                          | 43.34                          | 8.43             |
| Apple pomace .. ..  | 7.66                  | 3.48                          | 13.05                       | 5.20                          | 68.91                          | 1.70             |
| Beet pulp .. ..     | 7.66                  | 8.72                          | 20.53                       | 1.19                          | 58.74                          | 3.16             |
| Ground barley .. .. | 9.46                  | 8.20                          | 5.57                        | 1.47                          | 72.48                          | 2.82             |
| Ground oats .. ..   | 9.87                  | 9.52                          | 8.35                        | 4.74                          | 63.60                          | 3.92             |
| Millrun .. ..       | 10.42                 | 16.21                         | 4.53                        | 2.42                          | 63.27                          | 3.15             |
| EXPERIMENT II.      |                       |                               |                             |                               |                                |                  |
| Alfalfa hay .. ..   | 8.13                  | 13.60                         | 31.22                       | 2.51                          | 37.10                          | 7.73             |
| Apple pomace .. ..  | 9.87                  | 4.09                          | 11.87                       | 5.70                          | 66.71                          | 1.76             |
| Beet pulp .. ..     | 8.73                  | 8.65                          | 19.71                       | 0.59                          | 59.96                          | 2.36             |
| Ground barley .. .. | 8.46                  | 10.32                         | 6.92                        | 1.78                          | 69.21                          | 3.31             |
| Ground oats .. ..   | 8.48                  | 10.33                         | 10.35                       | 3.99                          | 63.11                          | 3.74             |
| Wheat bran .. ..    | 8.58                  | 14.76                         | 10.51                       | 5.13                          | 54.69                          | 6.33             |

Their conclusions contain the following points:—

- (i) Dried apple pomace moistened with 2.5 times its own weight of water proved to be a palatable feed for dairy stock.
- (ii) The dried apple pomace groups of cows produced approximately 93.5% as much milk as the dried beet pulp groups.
- (iii) The dried apple pomace did not affect the flavour or odour of the milk.
- (iv) Dried apple pomace furnishes a palatable feed of only slightly less value than dried beet pulp.
- (v) Moistened pomace may be fed at rate of 3 lbs. per 100 lbs. live weight daily.
- (vi) If used as part of a grain mixture, dried apple pomace must be balanced by a suitably high nitrogen constituent.

An American authority (81) states that "The residue from the pectin plant known as 'pectin pomace' also has value as feed, and is dehydrated for such use. It is higher in crude protein and ether extract and lower in available carbohydrate than dried apple pomace."

(c) Pomace as fuel. Pomace in Switzerland is dried, pressed into briquettes and used for fuel.

### B. *Soft fruit pomace*

The use of a pectin-decomposing enzyme in association with the milled fruit precludes the utilization of the press cake as a source of pectin. There is, however, a certain demand for the material from essence manufacturers for the extraction of the fruit flavouring substances which remain in the tissues. There is a definite tendency for the pomace to develop green mould at a very early stage unless it is treated at once, and it is usual to preserve the material by tight packing into casks with a liberal admixture of  $\text{SO}_2$ .

The pomace from soft fruits is not generally dried.

## METHODS OF ANALYSIS

### 33. Chemical analysis of fruit juice and other liquid products

The chemical composition of the fresh fruit juices which constitute the raw material for the fruit products factory varies between very wide limits from variety to variety and between different seasons. For attaining some degree of standardization from year to year, it is necessary to carry out a few very simple but important chemical determinations. Brief details only are given here of these methods; for a full discussion of all the various constituents and their determinations readers are referred to the publications by Cruess, Joslyn and Saywell (45), and by Mehrlitz (66).

#### A. *Preparation of sample*

It is necessary to remove most of the gas in the juice or other product, should it be in an aerated condition. This can be effected by pouring the juice from beaker to beaker, by filtering the juice several times through rough filter paper, or finally, by gently warming the samples until the evolution of gas ceases. The juice, freed from  $\text{CO}_2$  should be brought to room temperature before being measured by pipettes, etc.

#### B. *Specific gravity*

The specific gravity of a juice is to some extent proportional to its sugar content and is often used as a convenient means of expressing the relative sweetness of different juices. The determination is very simple. A specific gravity hydrometer is floated in the juice from which the gas must have been removed. The gravity is read off directly from the scale on the neck of the instrument. Small differences of temperature have little effect on the accuracy of the determination, but in cases of very low or very high temperatures, the juices should first be brought to normal conditions. A suitable range for a hydrometer for fruit juices is 1.000-1.060. Black currant juice which may have a gravity higher than 1.060, and is extremely viscous in its fresh condition, must be broken down with 3.5 volumes of water in order to obtain an accurate figure.

Warcollier (84) quotes a table by Lechartier giving the sugar contents equivalent to a given specific gravity for apple juice. The following table, taken from the more complete data, indicates the general relationship :—

| Specific Gravity. | Sugar Percentage. |
|-------------------|-------------------|
| 1.060             | 12.9              |
| 1.055             | 11.8              |
| 1.050             | 10.6              |
| 1.045             | 9.5               |
| 1.040             | 8.4               |
| 1.035             | 7.4               |
| 1.030             | 6.3               |

#### C. *Total acidity*

10 c.c. of juice, prepared as above, are pipetted into a small beaker and titrated with caustic soda solution (0.149 N; 1 c.c. = 0.01 gr. malic acid). The progress of the neutralization

can generally be seen in the changing colour of the juice, but the end-point, denoting exact neutralization, must be determined by the use of blue litmus in the usual way. The soda is added drop by drop until the application of a small drop to the litmus paper by means of a pointed glass rod no longer turns the litmus red. The reading in ccs. soda used is divided by 10, thus giving the percentage of malic acid in the product.

Examples :—Titration = 5.7 c.c. Malic acid = 0.57%.  
 „ = 11.6 c.c. „ „ = 1.16%.

#### D. Tannin

This estimation is particularly useful when bitter fruit is available and when it is desired to blend the astringency equally throughout other bulks of juice. A 400 c.c. flat-bottomed flask is used. About 200 c.c. water, 1 c.c. fruit juice and 5 c.c. of indigo solution \*(Solution A) are added and mixed. The titration is carried out with potassium permanganate\* (Solution B), until the blue colour changes to green and finally through several intermediate shades to a clear yellow. Considerable practice is needed before this end-point can be correctly ascertained, but by viewing the mixture by reflected light the colour changes are more easily seen. For calculating the “ tannin ” content the permanganate titration is reduced by one, and the result divided by 10.

Examples :—Titration 3.4 c.c. Tannin percentage 0.24%.  
 „ 1.9 c.c. „ „ 0.09%.

Should the titration be in excess of 5.0 c.c. it is advisable to commence with 0.5 c.c. of juice.

It should be emphasized that this method does not give a true tannin figure, but the data obtained by this means does bear a definite positive relationship to the astringency of the juice and is a sufficient guide for blending work.

##### \*Solution A.

Dissolve 2 grams indigo carmine in 500 c.c. water by boiling. Cool, add 50 c.c. concentrated sulphuric acid and make up to 1 litre. This solution is diluted until 5 c.c. are exactly decolorized by 1 c.c. of potassium permanganate solution (Solution B).

##### \*Solution B.

Dissolve 0.785 grams potassium permanganate in 1 litre water.

#### E. Alcohol

Measure 100 c.c. juice into a conical flask (400 c.c.) attached to a 2-bulb column and metal condensing water system. Heat gently and distil over about 80 c.c., collecting the liquid in a 100 c.c. graduated flask. Fill up the flask to the base of the neck with distilled water, bring to standard temperature, bulk and determine alcohol content by a specific gravity bottle.

#### F. Sulphur dioxide

A simple and quick method of determining  $\text{SO}_2$  in fruit juices is available. The results are generally very comparable with the figures obtained by the Monier-Williams method.

50 c.c. juice are shaken at intervals with 25 c.c. N caustic potash solution. After 15 minutes 10 c.c. (1+3) sulphuric acid are added, and the acidified mixture is titrated with  $\frac{\text{N}}{50}$  iodine, using starch as an internal indicator. The titration figure multiplied by 0.896 gives the results in grains per gallon (7 grains per gallon = 100 parts per million).

### COMPOSITION OF APPARATUS

#### 34. Choice of metals for equipment

The well-known corrosive effect of fruit juices on certain metals such as copper, lead, zinc, and aluminium, necessitate the careful choice of material for plant or storage of juice (33).

For cold fruit juices, copper, lead and zinc are quite unsatisfactory and should not be allowed to come into contact, even for a short period, with the juices. Aluminium of high

purity is dissolved to some extent and cannot be generally recommended. It is usual to coat copper with tin, and although the latter metal is removed gradually, the filter or other piece of apparatus can generally be left for two seasons before it needs retinning. Stainless steel, Staybrite and Monel metal have been tested at Long Ashton on several occasions and appear to be the most resistant material for fruit juices. These alloys are, however, difficult and expensive to work and for some types of plant silvered surfaces are preferable.

A new process is available for "metallizing" the various metals as a fine layer on to existing plant. Stainless steel is included in the list of metals which can be sprayed on to existing plant for juice equipment, and this method may prove of considerable use if the metal is sprayed until a thick enough deposit is built up.

For pumps, etc., gun metal and acid resisting bronzes are quite satisfactory, but so many "white metals" of differing compositions are available that it is impossible to generalize regarding their behaviour. Cupro-nickel is fairly resistant to fruit juices.

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MESSRS. UNIVERSAL BREWERY EQUIPMENT, LTD., Croydon, London. Fig. 27.

## GLOSSARY

|                           |                                                                                                                                                                     |
|---------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <i>Aeration.</i>          | The process of dissolving carbon dioxide gas into fruit juices.                                                                                                     |
| <i>Astringency.</i>       | The bitter taste in fruit juices, due to the presence of tannin compounds.                                                                                          |
| <i>Bakelite.</i>          | A synthetic resin material recently introduced in Germany for pipes, tubes, tank linings, etc.                                                                      |
| <i>Baumann caps.</i>      | Special rubber caps for sealing glass jars of 5-10 gallons capacity.                                                                                                |
| <i>Bittersweet.</i>       | Important type of cider apples grown extensively in Normandy and in the S.W. counties of England, and possessing low acidities but relatively high tannin contents. |
| <i>Boehi tanks.</i>       | Steel tanks of strong construction for the reception of apple juice impregnated with carbon dioxide at a pressure of 120 lbs. per square inch.                      |
| <i>Callandria.</i>        | A device for rapidly heating juices to be evaporated in vacuo without any danger of over-heating.                                                                   |
| <i>Calvados.</i>          | French cider brandy.                                                                                                                                                |
| <i>Carbonation.</i>       | See Aeration.                                                                                                                                                       |
| <i>Carbon dioxide.</i>    | A gas used for the aeration of fruit juices.                                                                                                                        |
| <i>"Cheese".</i>          | The finished erection of layers of fruit tissue contained in cloths separated by wooden racks.                                                                      |
| <i>Cider.</i>             | The fermented juice of the apple. Not to be confused with "sweet cider" (Canada and U.S.A.), which is unfermented juice.                                            |
| <i>Citral.</i>            | A strongly smelling constituent of various citrus juices.                                                                                                           |
| <i>Closures.</i>          | Any means of effectively closing filled bottles or cans of juice (i.e. corks crown corks, composition seals and screw stoppers).                                    |
| <i>Cloths.</i>            | Squares of cotton, woollen or mixture materials for retaining the milled apple tissue in the "cheese".                                                              |
| <i>Composition seals.</i> | Seals composed of cork in combination with other materials for the closing, of bottles or cans.                                                                     |
| <i>Concentration.</i>     | A method of removing water from fresh fruit juices either by evaporation by heat (hot process) or by freezing.                                                      |
| <i>Crown cork.</i>        | Patent metal seal with cork insert protected by special parchment lining treated with various materials.                                                            |
| <i>Deaeration.</i>        | The removal of dissolved air from freshly expressed or semi-processed fruit juices.                                                                                 |
| <i>Detergents.</i>        | Chemical compounds, mostly containing caustic soda, for the cleansing of bottles from grease, dirt and micro-organisms.                                             |
| <i>Dukeron.</i>           | Material for interior lining of casks or other vessels.                                                                                                             |
| <i>Ebon.</i>              | Swiss material very widely used for the lining of concrete tanks or pressure vessels for storage of fruit juices and cider.                                         |
| <i>Enzymes.</i>           | Commercially prepared materials capable of breaking down the pectic compounds in fresh fruit juices into simpler materials.                                         |
| <i>Elanchit.</i>          | French material for lining storage vessels.                                                                                                                         |
| <i>Evaporator.</i>        | Plant for removing water from fruit juices by evaporation in vacuo.                                                                                                 |

|                                |                                                                                                                                                                                                                        |
|--------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <i>Flash pasteurization.</i>   | A method of sterilizing fruit juices by subjecting them to high temperatures for a very short period of time.                                                                                                          |
| <i>Flocks.</i>                 | Voluminous masses of flocculent material formed in fruit juices by the interaction of gelatin and tannin.                                                                                                              |
| <i>Freezing method.</i>        | The removal of water from fruit juices by freezing and subsequent centrifugation of the ice from the concentrated juice.                                                                                               |
| <i>Gaschell.</i>               | Swiss material for the lining of storage vessels.                                                                                                                                                                      |
| <i>Gelatin and tannin.</i>     | Chemical compounds used in combination for the clarification of fruit juices.                                                                                                                                          |
| <i>Hard cider.</i>             | Cider which has become acetic, i.e. in which some of the alcohol has been converted by bacterial action into acetic acid, the characteristic constituent of vinegar.                                                   |
| <i>Holding pasteurization.</i> | A method of sterilizing fruit juices by maintaining them at a relatively low temperature for a period between 20-30 minutes.                                                                                           |
| <i>Katadyn process.</i>        | An electrical process for the sterilization of fruit juices involving the use of metal electrodes.                                                                                                                     |
| <i>Keiving.</i>                | Process of French origin for the purpose of inducing a separation of solid material in juices expressed from cider apples. Top and bottom deposits are formed and the clear juice is removed from the vats by racking. |
| <i>Kieselguhr.</i>             | Purified material obtained from natural deposits of diatomaceous earth. Used for filtration purposes.                                                                                                                  |
| <i>Kirsch.</i>                 | Continental term for cherry brandy and related products.                                                                                                                                                               |
| <i>Knot formation.</i>         | The formation of small, hard aggregates of pulp in cotton-asbestos filter pulp.                                                                                                                                        |
| <i>Limonene.</i>               | A characteristic constituent of lemons.                                                                                                                                                                                |
| <i>Lithcote.</i>               | An American material for the lining of metal vessels for the storage of juices and wines, or for fermentation vats.                                                                                                    |
| <i>Maceration.</i>             | A French process in which the milled apples are allowed to stand for several hours prior to being pressed.                                                                                                             |
| <i>Mamut-Ventur.</i>           | French material for lining storage vessels.                                                                                                                                                                            |
| <i>Marry.</i>                  | The process of maturing which proceeds when different juices are blended together. The flavours of the various constituent juices are said to "marry" as maturing proceeds.                                            |
| <i>Matzka process.</i>         | A process for the sterilization of fruit juices involving low temperature treatment and the use of a silver tube whereby minute quantities of silver pass into solution.                                               |
| <i>Mealy pulp.</i>             | The condition of the pulp from certain varieties of apples when milled in immature or over-mature conditions. In these circumstances the juice is difficult to express from the pulp.                                  |
| <i>Milk shake.</i>             | A whipped mixture of milk, ice cream and fruit syrup.                                                                                                                                                                  |
| <i>Minerals.</i>               | Minor constituents of fruit juices (i.e. salts of potassium, sodium, calcium, aluminium, iron, magnesium, etc.)                                                                                                        |
| <i>Monel metal.</i>            | An alloy containing copper which is highly resistant to fruit juices.                                                                                                                                                  |
| <i>Most-Max tank.</i>          | A thin steel container with porcelain lining for the dispensing of apple juice in hotels, hospitals, schools, etc.                                                                                                     |
| <i>Natural conditioning.</i>   | The process of bottling medium sweet ciders in March and April and allowing a regulated secondary fermentation to take place in the bottled product.                                                                   |

|                                  |                                                                                                                                                                                            |
|----------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <i>Oligodynamic action.</i>      | The action of very minute quantities of certain metals in the colloidal state in sterilizing micro-organisms.                                                                              |
| <i>Pectin.</i>                   | A complex chemical compound occurring in fruits and fruit juices.                                                                                                                          |
| <i>Pfaudler tank.</i>            | American tank with so-called glass lining. Widely used for evaporation of juices.                                                                                                          |
| <i>Pomace.</i>                   | The once- or twice-pressed residue remaining in the cloths after hydraulic pressing. The term is sometimes used for the dried product.                                                     |
| <i>Potassium metabisulphite.</i> | A chemical compound containing approximately half its weight of sulphur dioxide. A convenient material to use for the preservation of fruit juices, where allowable.                       |
| <i>Presscake.</i>                | See Pomace.                                                                                                                                                                                |
| <i>Racking.</i>                  | A simple cider-making process consisting in pumping off the top liquor from the sediment of fruit tissue or yeast deposit.                                                                 |
| <i>Racks.</i>                    | Wooden frames used to separate the cloths containing the milled fruit tissue in the "cheese".                                                                                              |
| <i>Scheidmost.</i>               | A natural material obtained from fruit which is capable of decomposing pectic material in juices. Certain varieties of pear are used in Switzerland for the same purpose.                  |
| <i>Schoof process.</i>           | A Swiss process for the processing of apple juice by the cold method.                                                                                                                      |
| <i>Seitz E.K. Filter.</i>        | A form of filter capable of sterilizing fruit juices when fitted with special E.K. filtering discs.                                                                                        |
| <i>Seitz Satrap.</i>             | Machine for the removal of residual sulphur dioxide from bottles subsequent to their treatment on a sulphuring wheel.                                                                      |
| <i>Sludge.</i>                   | Various treatments for the clarification of fruit juices result in the formation of a heavy deposit of very finely divided materials of fruit origin which are generally termed "sludges". |
| <i>Sorbit.</i>                   | Chemical compound which occurs in some fruit juices and is presumed to be of importance for nutrition.                                                                                     |
| <i>Squashes.</i>                 | Sweetened fruit juices containing a certain proportion of fruit tissue.                                                                                                                    |
| <i>Stabilization.</i>            | Treatment of fruit products to prevent subsequent alterations in composition or flavour on account of fermentation or chemical changes.                                                    |
| <i>Stainless steels.</i>         | A series of special alloys containing, in general, 18% of chromium and 8% of nickel. The alloys are very resistant to fruit juices.                                                        |
| <i>Staybrite.</i>                | A form of stainless steel.                                                                                                                                                                 |
| <i>Sterilization.</i>            | The process of killing all micro-organisms in fruit products.                                                                                                                              |
| <i>"Stuck" fermentation.</i>     | Fermentation which has ceased prior to the complete removal of sugar.                                                                                                                      |
| <i>Sulphur dioxide.</i>          | A gas used for the sterilization of bottles, etc., or for exerting a preservative action on fruit products.                                                                                |
| <i>Sweet cider.</i>              | Canadian and American term for unfermented apple juice.                                                                                                                                    |
| <i>Syrups.</i>                   | Clear fruit products produced by the incorporation of considerable amounts of sugar in fruit juices.                                                                                       |
| <i>Tannins.</i>                  | Astringent (bitter) compounds occurring in fruit and fruit juices.                                                                                                                         |
| <i>Viscometer.</i>               | A physical instrument for determining the viscosity of fruit juices. Used for following the progress of pectin removal by enzyme action.                                                   |
| <i>Vitamins.</i>                 | Accessory food factors of great importance for the maintenance of health.                                                                                                                  |
| <i>Yeasts.</i>                   | Micro-organisms occurring naturally in all fruit material and fruit juices and responsible for fermentation.                                                                               |

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